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NAVAL POSTGRADUATE SCHOOL

Monterey , California



THESIS

C5023

OFF-DESIGN LOSS MEASUREMENTS IN A COMPRESSOR CASCADE

by

Michael A. Classick

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September 1989

Thesis Advisor:

Raymond P. Shreeve

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OFF-DESIGN LOSS MEASUREMENTS
IN A COMPRESSOR CASCADE

by

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Lieutenant Commander, United States Navy
B.S., University of Oregon, 1977

Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
September 1989

ABSTRACT

Data acquisition software was written to recover the ability to make loss measurements using a five-hole pneumatic probe in a wind tunnel facility currently containing a modeled subsonic cascade of controlled diffusion (CD) stator blades. Acquisition, reduction and ancillary programs were written for a Hewlett Packard 9000 Series 300 computer/HP 3052 Data Acquisition System in HP BASIC 5.0. The new software was demonstrated and validated by conducting a set of surveys at the (near to stall) air inlet flow angle of 48 degrees. The survey results showed a diminishing core of two-dimensional flow through the blading due to side wall boundary layer effects, and integration of upstream and downstream measurements gave an axial velocity-density ratio of 1.108 and a NASA loss coefficient of 0.097. Prior to the surveys, the probe was calibrated in a free jet facility, thus also revalidating the calibration software. It was concluded that the facility instrumentation and procedures were now in place for making accurate off-design loss measurements on a routine basis.

THESIS DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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LIST OF SYMBOLS

English Letter Symbols

AVDR	Axial Velocity Density Ratio
C_P	Pressure coefficient
$\overline{C_P}$	Mass averaged coefficient of pressure from instrumented blade
C_{P_2}	Static pressure rise coefficient
c	Chord
c_p	Specific heat at a constant pressure
h	Span-wise depth of control volume
M	Mach number
n	Number of scans
P	Pressure
Q	Dynamic pressure ($1/2 \rho V^2$)
s	Blade spacing
T	Temperature
V	Velocity
X	Nondimensional velocity
x	Position of probe in blade-to-blade direction

Greek Letter Symbols

β	Flow angle
γ	Ratio of specific heats
ω	Loss coefficient
ρ	Density

Subscripts

1	Upstream survey station
2	Downstream survey station
a	Atmospheric
l	Local
p	Measured in the plenum
ref	Reference value derived from plenum stagnation pressure
s	Static
t	Stagnation or total

Superscripts

[^]	Ensemble average of values during a survey
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I. INTRODUCTION

Off-design compressor performance is becoming more important as future engine design goals involve higher thrust-to-weight ratios, lower specific fuel consumption, and smaller size. Currently, great demands on the engine are made during high angle-of-attack flight by fighter aircraft and by VSTOL and rotorcraft operating in flight conditions that greatly distort the flow to the compressor. Design goals and extreme operating conditions push the compressor operating point towards the stall boundary. Thus, it is vitally important to have methods for predicting stall margin in the process of design.

The modeling of compressor flows using computational fluid dynamic (CFD) codes is the key to such a development, and cascade data on flow structure and blade element behavior are required to validate the codes. While flow structure of the velocity field can be mapped using a laser doppler velocimeter (LDV) system, it is the loss coefficient (introduced in Chapter VI of Ref. 1) which is the essential integral measure of the blade element performance. The focus of the present work was to recover the ability to make loss measurements using a pressure probe in the Naval Postgraduate School's (NPS) cascade facility.

In the present study, the cascade was configured with the mid section of a controlled diffusion (CD) stator blade designed by Sanger [Ref. 2] at NASA Lewis Research Center.

Previous studies using CD blading in this facility include the work of Koyuncu [Ref. 3], who conducted fourteen tests at air inlet angles from 24.3 degrees to 47.2 degrees to measure blade performance using pressure probes. Dreon [Ref. 4] followed with probe studies at air inlet angles of 40.3 degrees and 43.4 degrees, concentrating on verifying the accuracy of the loss measurements. Dreon's work is cited frequently throughout the present report since much of what he did, in principle, was used to guide the present work. Elazar [Ref. 5] performed detailed measurements of inviscid flow in the passage between two adjacent blades, the boundary layer development on the blade surfaces and the early wake development using a two-component LDV system. Baydar [Ref. 6] made wake measurements using hot wires to verify the LDV wake measurements made by Elazar. In these earlier studies, the cascade flow was found to be acceptably uniform and periodic (each blade passage the same), and showed good span-wise independence. Cascade flow quality was initially analyzed by NACA [Ref. 7] and first addressed at NPS by Duval [Ref. 8].

The necessity for the present work arose when an obsolete and unsupported computer was replaced by a Hewlett Packard 300 PC in an upgrade of the facility's data acquisition system. Entirely new software was required to be written (using HP BASIC 5.0) to replace the many previous programs. A simple translation of the previous software was not attempted in view of the undocumented

modifications generated by a series of previous investigators. The new software is described fully in Appendix B.

Overall, recovering the ability to make loss measurements involved first, the calibration of a five-hole conical pressure probe (Appendix A), second, developing the required acquisition and reduction software and third, obtaining a complete set of preliminary measurements at an air inlet angle of 48 degrees to demonstrate and validate all aspects of the procedure. The conclusion of the study was that the calibrated probe and data acquisition system are indeed operational, and ready to be used to make surveys and loss measurements in the cascade.

Section II of this report describes the experimental apparatus, namely the cascade facility, instrumentation and the data system. Section III addresses the test conditions, calibration, procedures, method of referencing, and outlines the measurements that were made. The results are presented and discussed in Section IV followed by conclusions and recommendations in Section V. Appendix A contains the details of the probe calibration. Appendix B contains a complete description of the new software, with listings of all programs and samples of the printed output tables. Appendix B is intended to serve as a description and user guide to the software. Finally, Appendix C outlines procedures for referencing the probe yaw angle.

II. EXPERIMENTAL APPARATUS

A. CASCADE WIND TUNNEL

The NPGS cascade facility is shown in Fig. 1. Figure 2 shows the test section. A detailed description of the facility, test section and CD blading is contained in Ref. 9.

B. CONTROLLED DIFFUSION BLADING

Reference 2 describes the CD blading in detail. A profile of blade and pressure tap locations on instrumented blades are shown in Fig. 3.

C. INSTRUMENTATION

The five-hole conical probe used and described by Dreon [Ref. 4] was calibrated and used for the probe measurements. Appendix A contains the calibration details.

The iron-constantan thermocouple, plenum pressure probe and instrumented CD blade were used as described by Dreon. Wall static pressure was measured from a centrally located tap upstream of the blades. A Prandtl probe was installed approximately midway between the inlet guide vanes and the test blading. The probe was located at mid span between blades 15 and 16, well clear of the probe survey locations. The Prandtl probe measurements provided an additional measure of tunnel conditions. The cone probe, plenum, wall static and Prandtl probe pressures were connected to a 48-port Scanivalve. A second Scanivalve sampled pressures

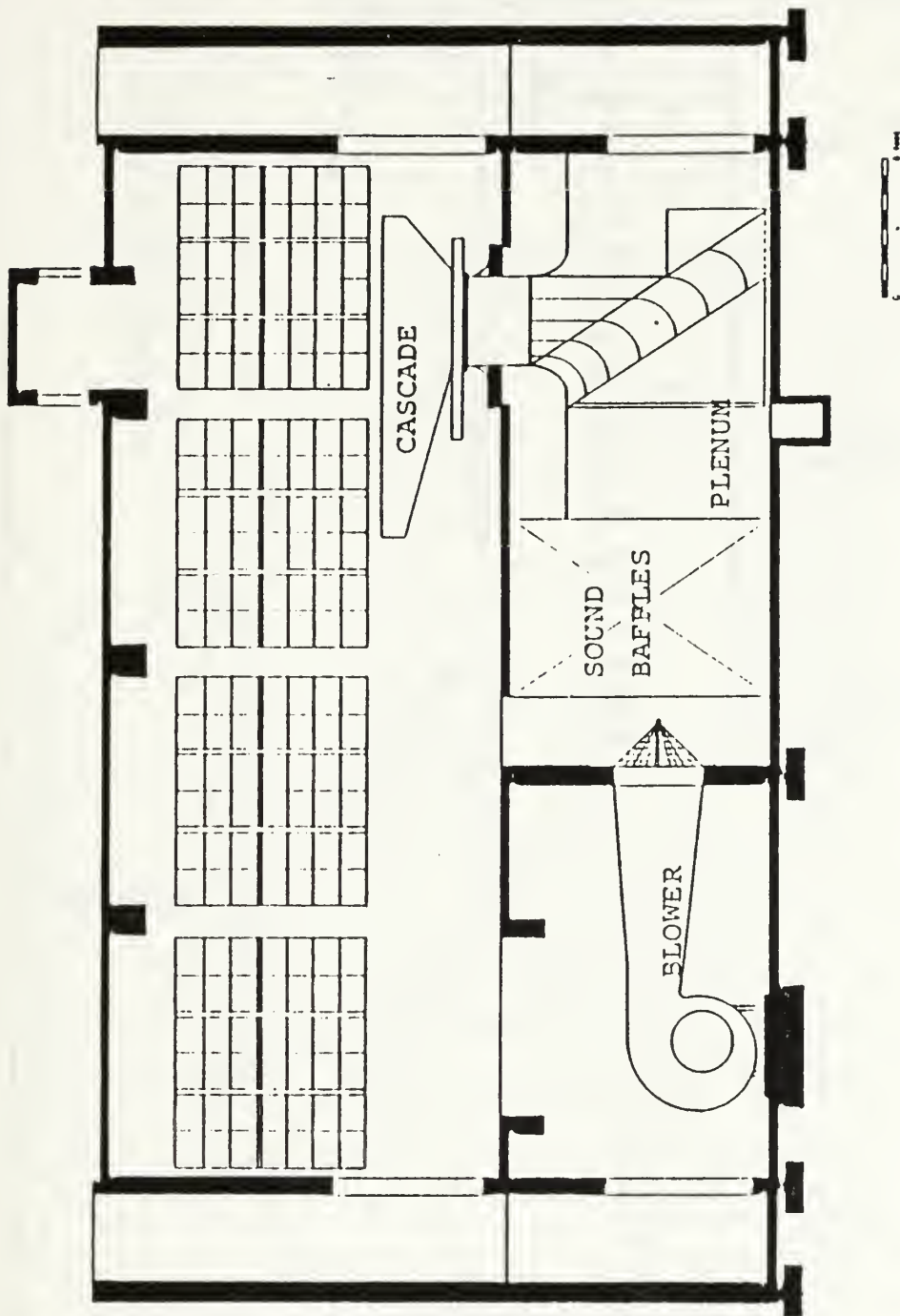


Figure 1. Cascade Wind Tunnel Test Facility

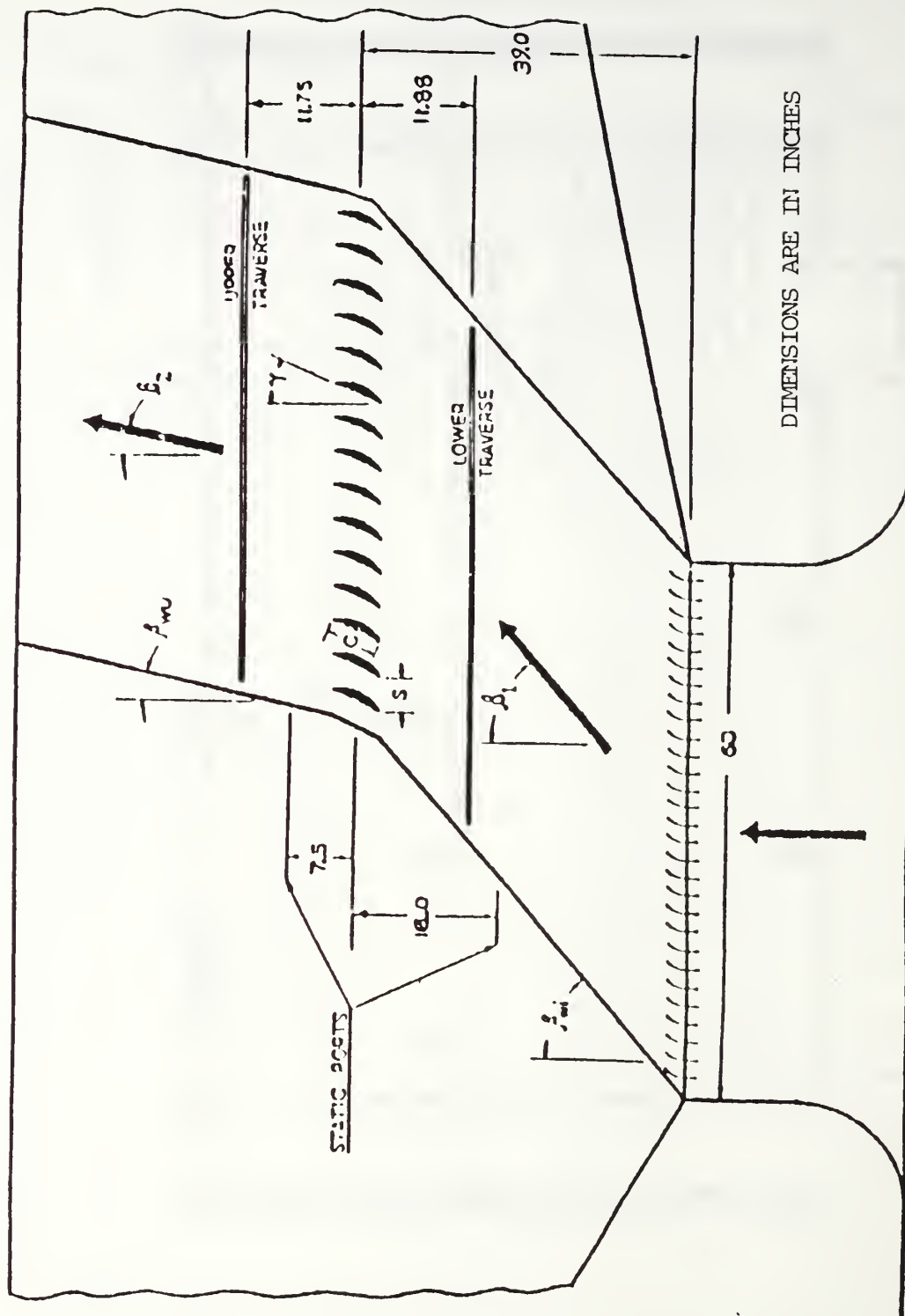


Figure 2. Cascade Test Section Schematic

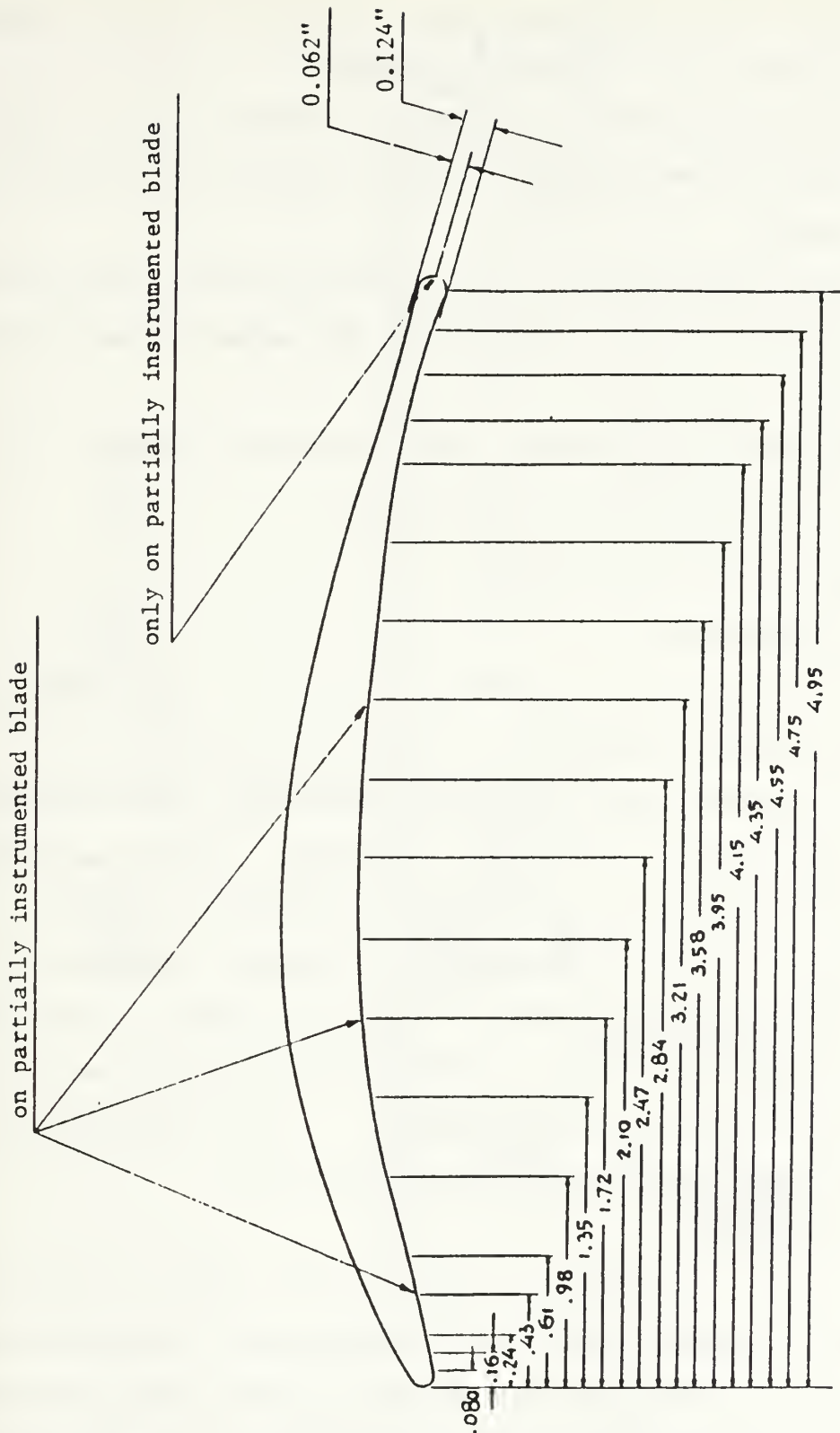


Figure 3. CD Blade Pressure Tap Locations

from the fully (blade 10) and one partially instrumented blade (blade 11), and from the plenum.

A yaw transducer on the conical probe, linear over the range used, provided the means to record inlet and outlet flow angles.

Probe displacement in the blade-to-blade direction was determined by a turn counter on the motor-driven traverse mechanism.

Span-wise displacement was recorded manually from a vernier scale attached to the probe.

D. DATA ACQUISITION SYSTEM

1. Hardware

A simplified schematic of the data acquisition system is shown in Fig. 4.

The data were collected using the Hewlett Packard Data Acquisition System (HP-3052) with instruments connected through an Interface Bus (HP-98034, HP-IB). The HG-78K Scanivalve controller, which controlled the selection and positioning of the Scanivalves is described by Geopfarth [Ref. 10]. A Hewlett Packard 900 series 300 computer controlled the system. The instrumentation channel assignments are given in Table B1.

2. Software

Three programs comprise the data acquisition software. Program "ACQUIRE" controls the acquisition and stores the collected data. Program "CALC" reduces the data to commonly used engineering quantities and "LOSS" computes

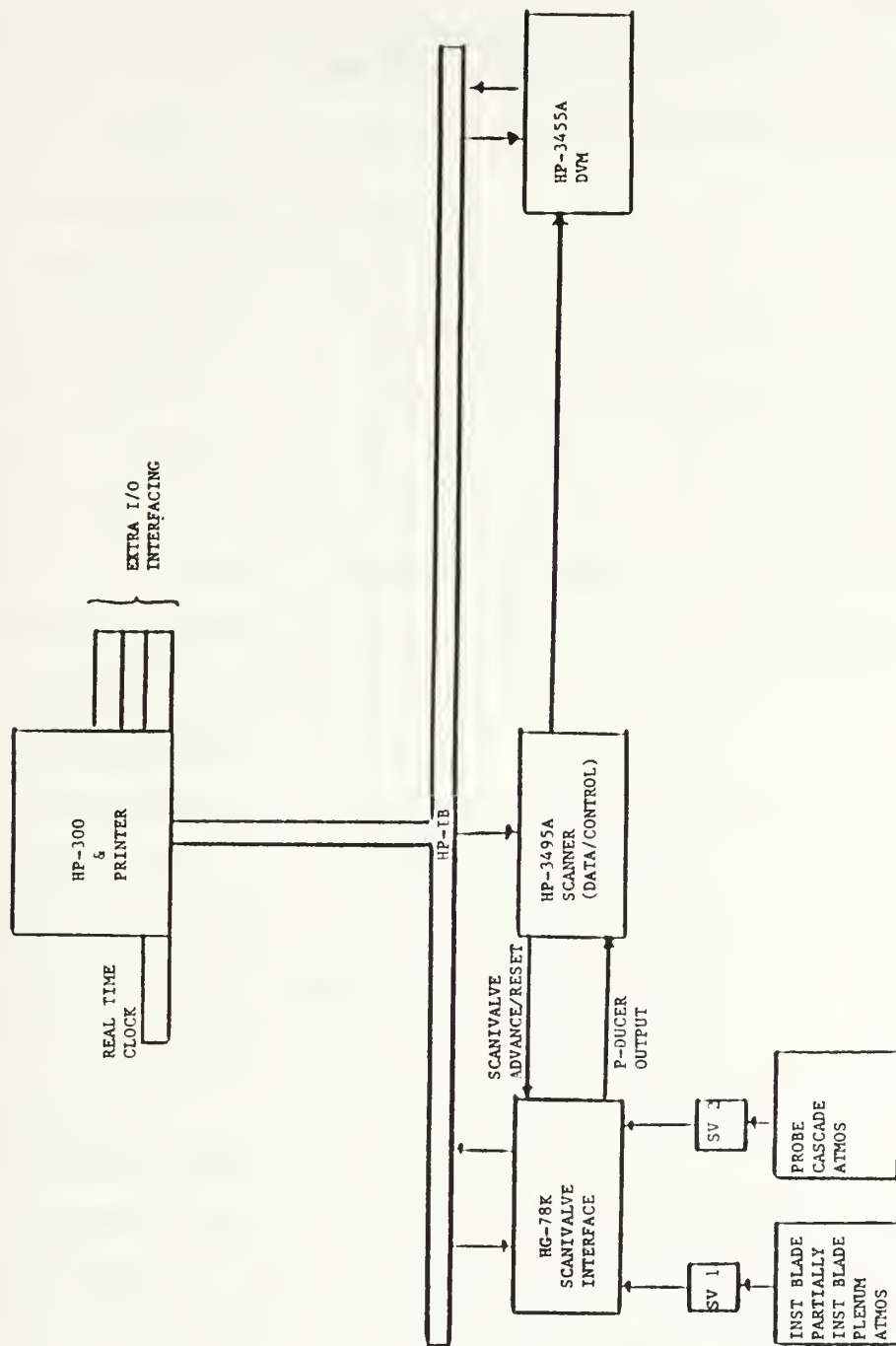


Figure 4. Data Acquisition System Block Diagram

the static pressure rise coefficient, axial velocity density ratio (AVDR) and loss coefficient. Software details are contained in Appendix B.

III. TEST PROCEDURES AND PROGRAM OF MEASUREMENTS

A. TEST PROCEDURES

1. Setting Test Conditions

Murray [Ref. 11], in a recently completed study, set the wall angle to 48 degrees for LDV measurements. A complete account of the angle setting procedure is given in Appendix A, Section VI of Ref. 11. All tests in the present study were conducted at a wall angle setting of 48 degrees and an inlet dynamic pressure (Q) of 17" H₂O. Atmospheric pressure was taken to be constant over the survey period of approximately two hours.

2. Calibration

The Scanivalves were calibrated prior to each test using shop air and a water manometer. The probe yaw transducer was scaled at two limiting settings prior to each test, having been shown previously to be linear to within 0.2 degrees--the resolution of the yaw vernier scale on the probe.

3. Referencing

Pressure and velocity values obtained by reducing probe test data at each probe position were referenced to the tunnel conditions at the time of the recording. This eliminated the effects that small changes in the tunnel supply conditions might have had on the calculation of the loss coefficient.

4. Data Points

The probe surveys consisted of a series of individual measurements at intervals ranging from .05 - .5 inches. At each interval, the probe was balanced in yaw (Appendix A) and measurements taken—defining a data point. The data collected were reduced using the equations given in Table I.

B. PROGRAM OF MEASUREMENTS

A summary of the probe surveys conducted in the present study is contained in Table II. First, a set of probe surveys was conducted to establish the flow quality into the cascade test section. Second, an inlet survey in the blade-to-blade direction was conducted to examine inlet uniformity. Span-wise surveys upstream and downstream of the blades were then made to examine two-dimensionality. Finally, detailed blade-to-blade, mid-span surveys over one blade passage were made upstream and downstream in order to compute the loss coefficient.

Upstream and downstream surveys were made at the traverse locations indicated in Fig. 2. Intervals between data points were decreased when a change in flow conditions was evident. Downstream span-wise surveys were located ± 1.2 inches from a vertical extension of the trailing edge of blade 9. Surface tap pressures were recorded from the instrumented blade after the last probe data point was recorded for the upstream blade-to-blade survey. Additionally, pressures were recorded from the partially

TABLE I. DATA REDUCTION FORMULAE

PARAMETER	EXPRESSION	PROGRAMMED EXPRESSION
X	$\left[\frac{\frac{\gamma-1}{2} M^2}{1 + \frac{\gamma-1}{2} M^2} \right]^{\frac{1}{2}}$	same
P _s	$P_t (1-X^2)^{\frac{\gamma}{\gamma-1}}$	same
V	$X [2 c_p T_p]^{\frac{1}{2}}$	$X [2 c_p (778 \times 32.174) T_p]^{\frac{1}{2}}$
Q	$P_t \left(\frac{\gamma}{\gamma-1} \right) X^2 (1-X^2)^{\frac{1}{\gamma-1}}$	same
$\hat{P}_p$	$\frac{1}{n} \sum_{n=1}^n P_p$	same
$\hat{T}_p$	$\frac{1}{n} \sum_{n=1}^n T_p$	same
X _{ref}	$\left[1 - \left(\frac{P_s}{P_p} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{1}{2}}$	same
V _{ref}	$X_{ref} [2 c_p T_p]^{\frac{1}{2}}$	$X_{ref} [2 c_p (778 \times 32.174) T_p]^{\frac{1}{2}}$
Q _{ref}	$P_p \left(\frac{\gamma}{\gamma-1} \right) X_{ref}^2 (1-X_{ref}^2)^{\frac{1}{\gamma-1}}$	same
$\hat{X}_{ref}$	$\left[1 - \left(\frac{P_s}{P_p} \right)^{\frac{\gamma-1}{\gamma}} \right]^{\frac{1}{2}}$	same
$\hat{V}_{ref}$	$\hat{X}_{ref} [2 c_p \hat{T}_p]^{\frac{1}{2}}$	$\hat{X}_{ref} [2 c_p (778 \times 32.179) \hat{T}_p]^{\frac{1}{2}}$

TABLE I. DATA REDUCTION FORMULAE (CONT.)

PARAMETER	EXPRESSION	PROGRAMMED EXPRESSION
$\hat{Q}_{ref}$	$\hat{P}_p \left(\frac{Y}{r_1} \right) \hat{X}_{ref}^2 (1 - \hat{X}_{ref}^2)^{\frac{1}{r_1}}$	same
* K		$\frac{P_t}{P_p} \frac{X}{X_{ref}} \left[\frac{1-X^2}{1-X_{ref}^2} \right]^{\frac{1}{r_1}} \cos \beta$
* AVDR	$\frac{h_1}{h_2}$	$\frac{\int_0^1 K_2 dx}{\int_0^1 K_1 dx}$
C_{P_t}	$\frac{P_t}{P_p}$	same
C_{P_s}	$\frac{P_s}{P_p}$	same
* $\bar{\omega}$	$\frac{(\bar{C}_{P_{t1}} - \bar{C}_{P_{t2}})}{(\bar{C}_{P_{t1}} - \bar{C}_{P_{s1}})}$	$\frac{\int_0^1 C_{P_{t1}} K_1 dx - \frac{1}{AVDR} \int_0^1 C_{P_{t2}} K_2 dx}{\int_0^1 C_{P_{t1}} K_1 dx - \int_0^1 C_{P_{s1}} K_1 dx}$
$\bar{C}_P$	$\left[\frac{P_1 \cdot P_s}{P_p \cdot P_s} \right] \left(\frac{\overline{P_p \cdot P_s}}{Q} \right) + \left(\frac{\overline{P_s \cdot P_s}}{Q} \right)$	$\left(\frac{P_1 \cdot P_s}{P_p \cdot P_s} \right) \frac{\int_0^1 \frac{P_p \cdot P_s}{Q} K_1 dx}{\int_0^1 K_1 dx} + \frac{\int_0^1 \frac{P_s \cdot P_s}{Q} K_1 dx}{\int_0^1 K_1 dx}$
C_{P_2}	$\left(\frac{\overline{P_{s2} \cdot P_s}}{Q} \right) + \left(\frac{\overline{P_s \cdot P_{s1}}}{Q} \right)$	$\frac{\int_0^1 \frac{P_{s2} \cdot P_s}{Q} K_1 dx}{\int_0^1 K_1 dx} + \frac{\int_0^1 \frac{P_s \cdot P_{s1}}{Q} K_1 dx}{\int_0^1 K_1 dx}$

* Derivation given in Ref. 8

TABLE II - PROBE SURVEYS

<u>SURVEY #</u>	<u>LOCATION</u>	<u>DIRECTION</u> (Length)	<u>NOMINAL</u> <u>INTERVAL</u> (in.)
1	UPSTREAM	BLADE-TO-BLADE (20 Blade Spaces)	.5
2	UPSTREAM	SPAN-WISE	.05 - .1
3	DOWNSTREAM (Pressure Side, 1.2")	SPAN-WISE	.05 - .1
4	DOWNSTREAM (Suction Side, 1.2")	SPAN-WISE	.05 - .1
5	UPSTREAM	BLADE-TO-BLADE (1 Blade Space)	.1
6	DOWNSTREAM	BLADE-TO-BLADE (1 Blade Space)	.05 - .1

instrumented blade to aid in establishing periodicity. Three data points were collected from the suction side and two from the pressure side. Further, a trailing edge tap on this blade provided base pressure.

IV. RESULTS AND DISCUSSION

A. FLOW FIELD

The probe surveys were considered to be preliminary and were conducted primarily to demonstrate and validate the new data acquisition software. The results were interesting, however, since they were the first to be obtained at an inlet angle of 48 degrees with the CD blading. Survey results are presented in Figs. 5-22 and tabulations of the detailed blade-to-blade and instrumented blade data are given in Appendix B, Tables B2 - B7.

1. Inlet Flow Field

The inlet flow field was seen to be acceptably uniform. Deviations from a fully uniform velocity were due to inlet guide vane wakes and non-uniformity in vane geometry. A non-uniform migration of the guide vane wakes is thought to explain the irregular profile of the inlet flow angle across the span, seen in Fig. 10.

2. Two-Dimensionality and Periodicity

Downstream span-wise surveys, located one inch to both the pressure and suction sides of the blade, show a diminishing core of two-dimensional flow. This was the result of side-wall boundary layer build-up through the test section. Flow properties were independent of span only over a limited displacement to the pressure side of the blade. The significant difference between the pressure

and suction side span-wise profiles was due, in part, to the probe being in the blade wake on the suction side.

Periodicity cannot be shown with results obtained over only one blade passage. However, the first and last points in the downstream survey over one blade passage in Fig. 20 can be seen to be in good agreement, which is required if the flow is truly periodic over successive passages. The degree to which periodicity was manifested was also seen in Fig. 23. Three values of the coefficient of pressure for the partially instrumented blade are shown plotted with the distribution of values for the fully instrumented blade. Values for two other taps, towards the leading and trailing edge on the suction surface, were omitted due to partial blockage of the pneumatic lines leading from these taps to the Scanivalve; otherwise, good agreement was noted.

B. BLADE ELEMENT PERFORMANCE

In the distribution of pressure shown in Fig. 23, a strong adverse pressure gradient is clearly indicated over the first ten percent of the blade chord on the suction side. The profile was similar in shape to those recorded in Dreon's [Ref. 4] and Elazar's [Ref. 5] work at inlet angles of 43.7 degrees and 46 degrees respectively. It is noted that the trailing edge (base) pressure on the partially instrumented blade gave $C_p = 0.253$.

From an integration of the data obtained in surveys 5 and 6 (Table II) using program "LOSS" (Appendix B), the AVDR was calculated to be 1.108 and the loss coefficient

was 0.097. The loss coefficient value is shown plotted in Fig. 24 where it can be seen in relation to Dreon's and Koyuncu's [Ref. 3] losses.

C. MEASUREMENT UNCERTAINTIES

All measurement uncertainties listed in Table I of Ref. 4 were the same for the present study except those for the inlet and outlet flow angles. The absolute values of the flow angle for the present data were not known to better than an uncertainty ± 2 degrees. The means to establish a pneumatic axis referenced to a precisely measured horizontal or vertical axis on the cascade was not available at the time of the measurements. The probe yaw angle readout was set to zero when the probe tip was judged to be pointing vertically downward. The inlet angle was subsequently observed to indicate approximately 48 degrees at the inlet station, consistent with Murray's [Ref. 11] observations. The yaw angles recorded during the tests were uncertain on an absolute basis; however, the relative flow angles recorded from the yaw transducer during the surveys were accurate to within 0.2 degrees.

The proposed method for obtaining absolute accuracy in the yaw angle measurements, using the optical accuracy of the LDV system for referencing, is given in Appendix C.

D. TABULATED AND PLOTTED QUANTITIES

The data from surveys 5 and 6 (Table II) are shown in Tables B2 - B5. The tables include values of the

Scanivalve gauge pressures, yaw transducer reading, plenum temperature (total temperature) and atmospheric pressure. Pressures are given in inches of water. Table B1 will aid in interpreting the scaled probe data.

Appendix B defines and describes the quantities Beta, Gamma and Phi which are listed in Tables B3 and B5. The ensemble averages given at the end of Tables B3 and B5 represent the nominal (ensemble averaged) test conditions for the survey. All other quantities can be interpreted using the List of Symbols and Table I.

$V1/V_{ref}$ VS PROBE DISPLACEMENT

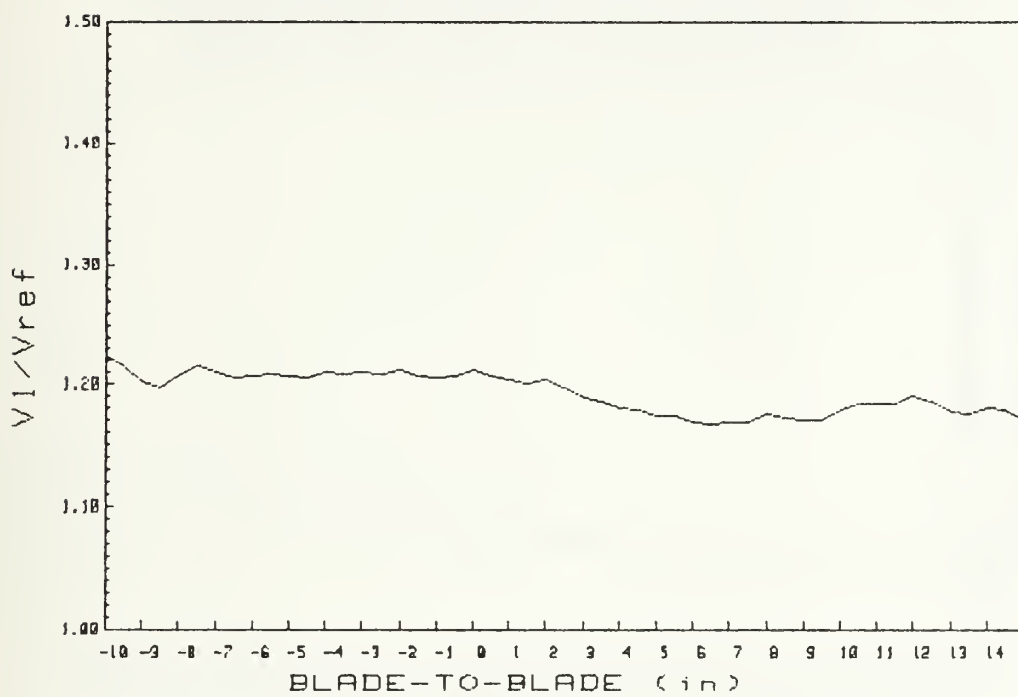


Figure 5. Inlet Survey: $V1/V_{ref}$ vs. Probe Displacement, Blade-to-Blade

Pref-Pt1/Qref VS PROBE DISPLACEMENT

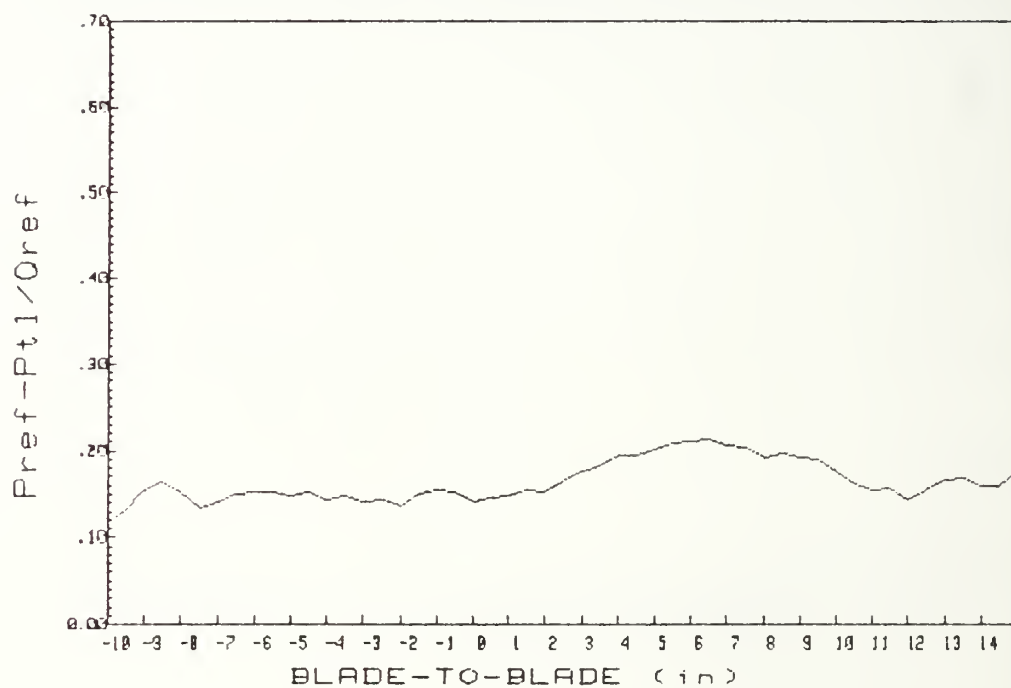


Figure 6. Inlet Survey: Pref-Pt1/Qref vs.
Probe Displacement, Blade-to-Blade

BETA1 VS PROBE DISPLACEMENT

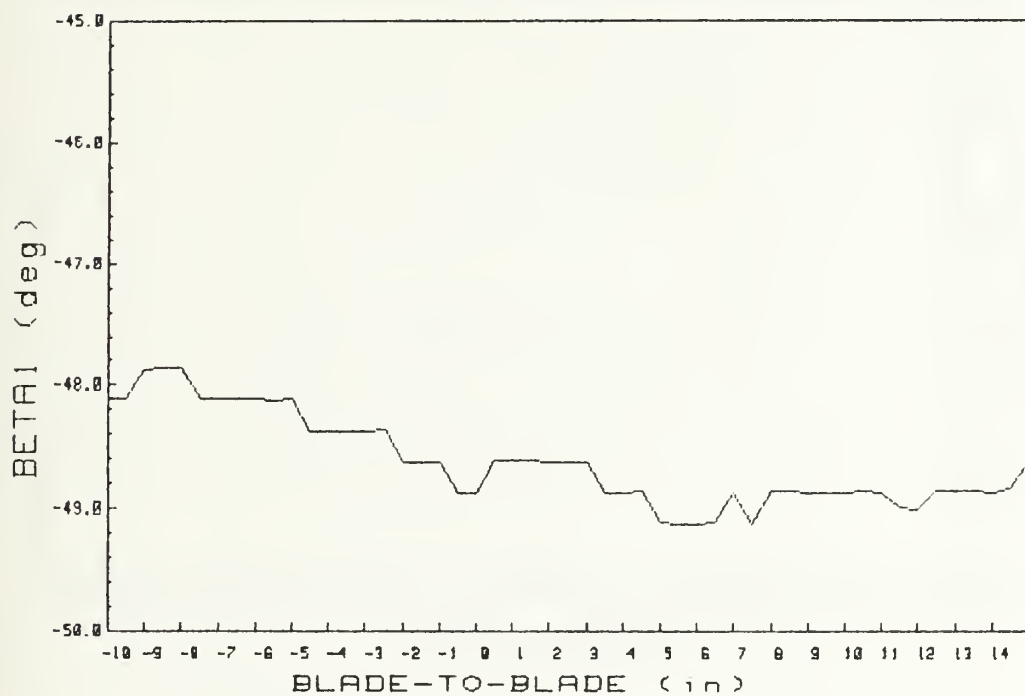


Figure 7. Inlet Survey: Beta1 vs. Probe Displacement, Blade-to-Blade

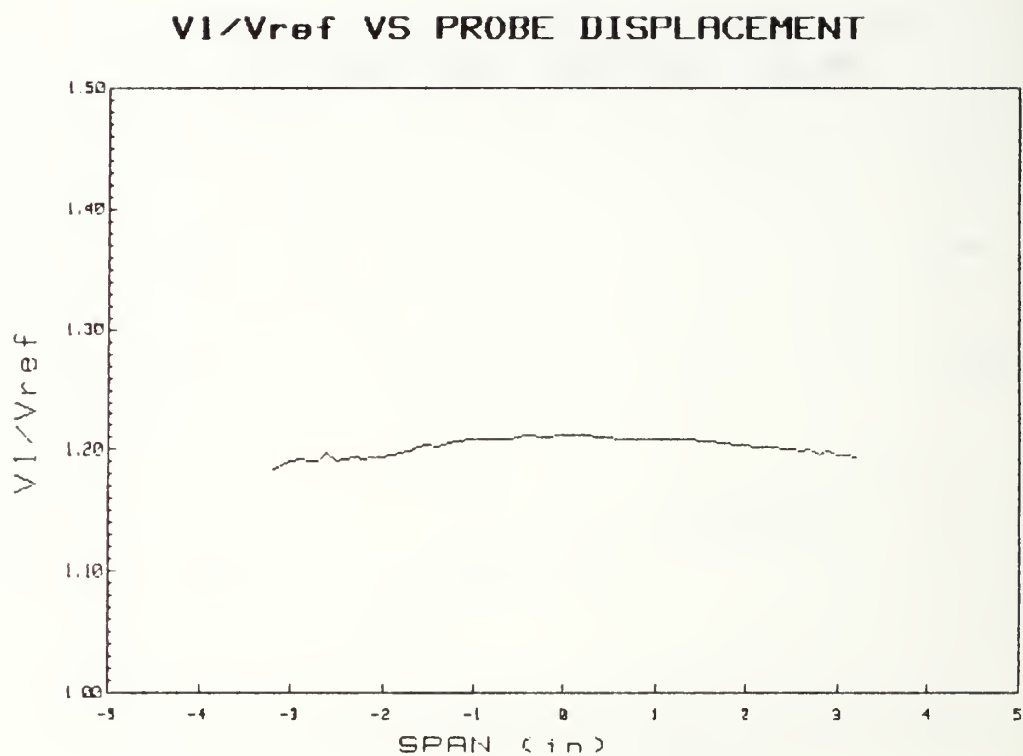


Figure 8. Inlet Survey: $V1/V_{ref}$ vs. Probe Displacement, Spanwise

Pref-Pt1/Qref VS PROBE DISPLACEMENT

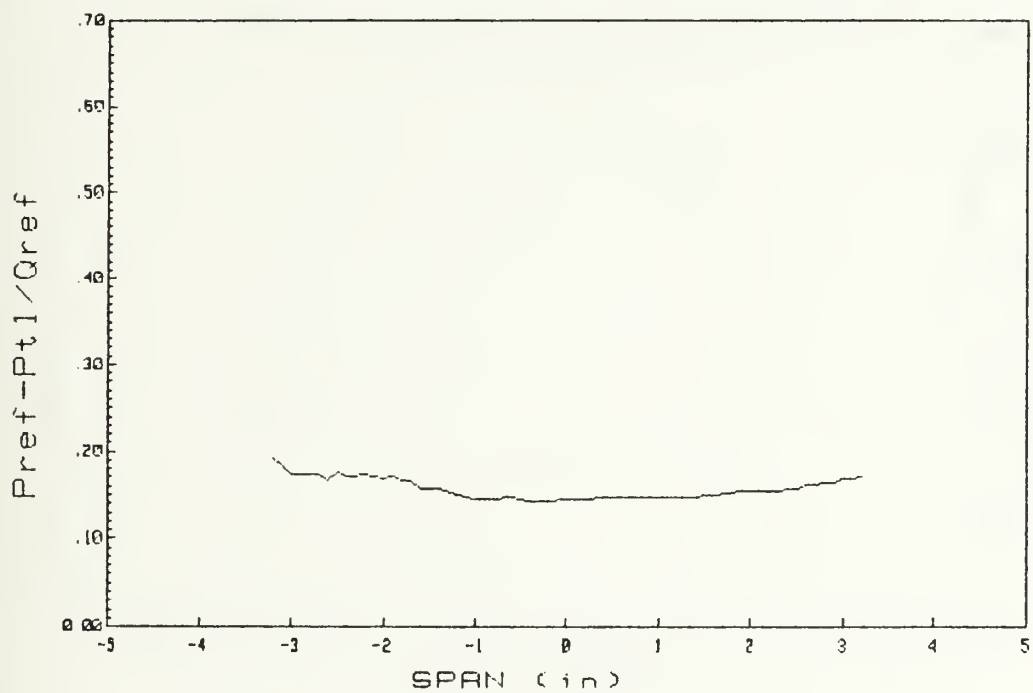


Figure 9. Inlet Survey: Pref-Pt1/Qref vs.
Probe Displacement, Spanwise

BETA1 VS PROBE DISPLACEMENT

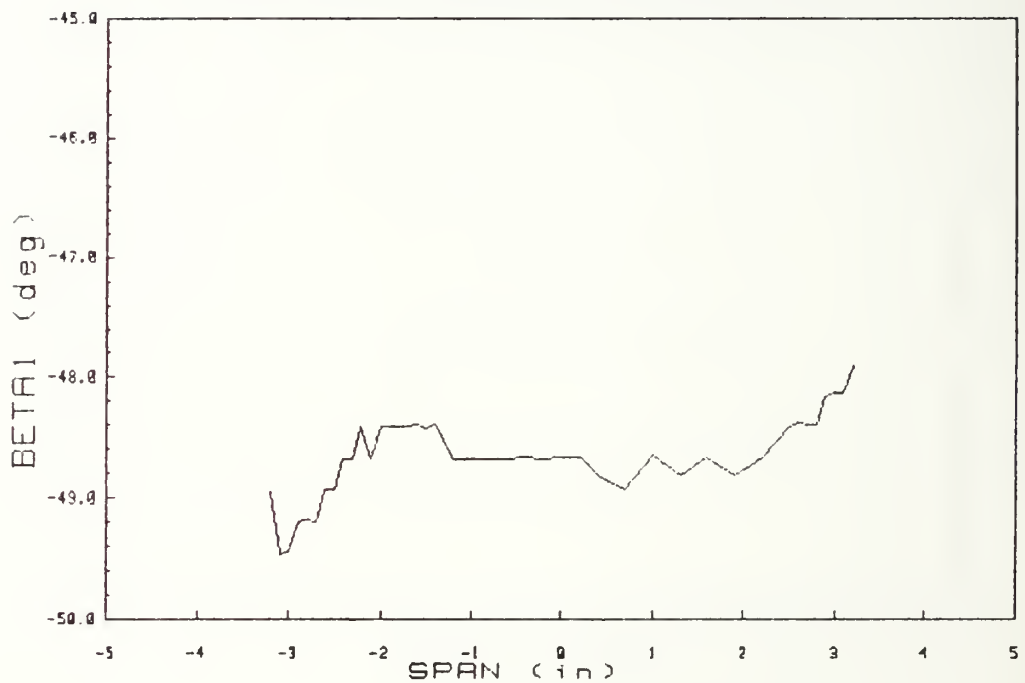


Figure 10. Inlet Survey: Beta1 vs. Probe Displacement, Spanwise

V2/Vref VS PROBE DISPLACEMENT

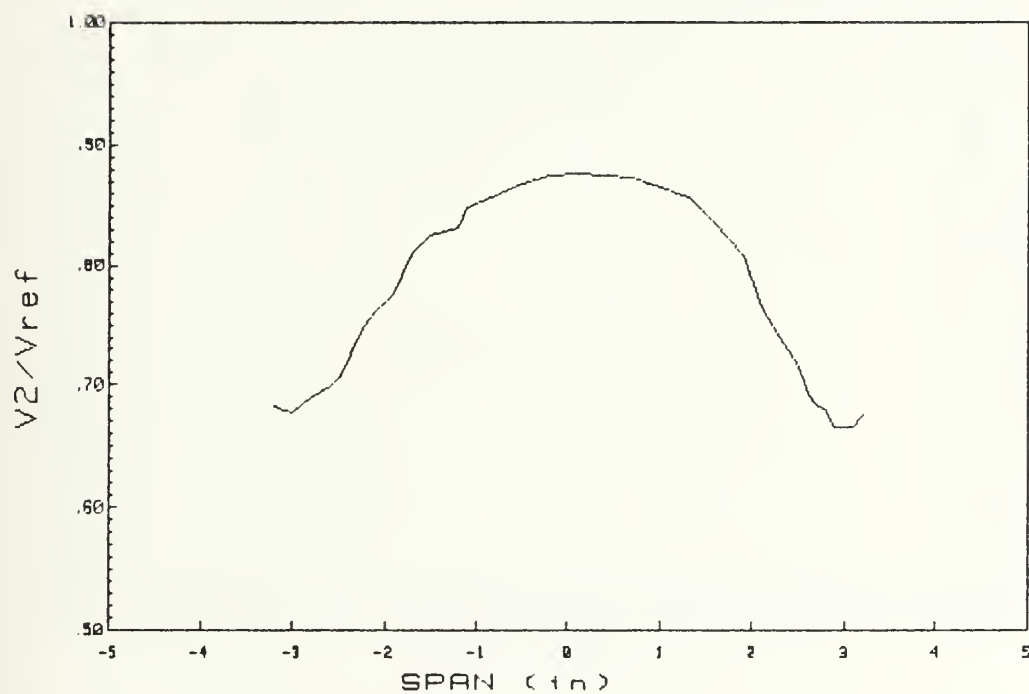


Figure 11. Outlet Survey: V2/Vref vs. Probe Displacement, Spanwise (Pressure Side)

Pref-Pt2/Qref VS PROBE DISPLACEMENT

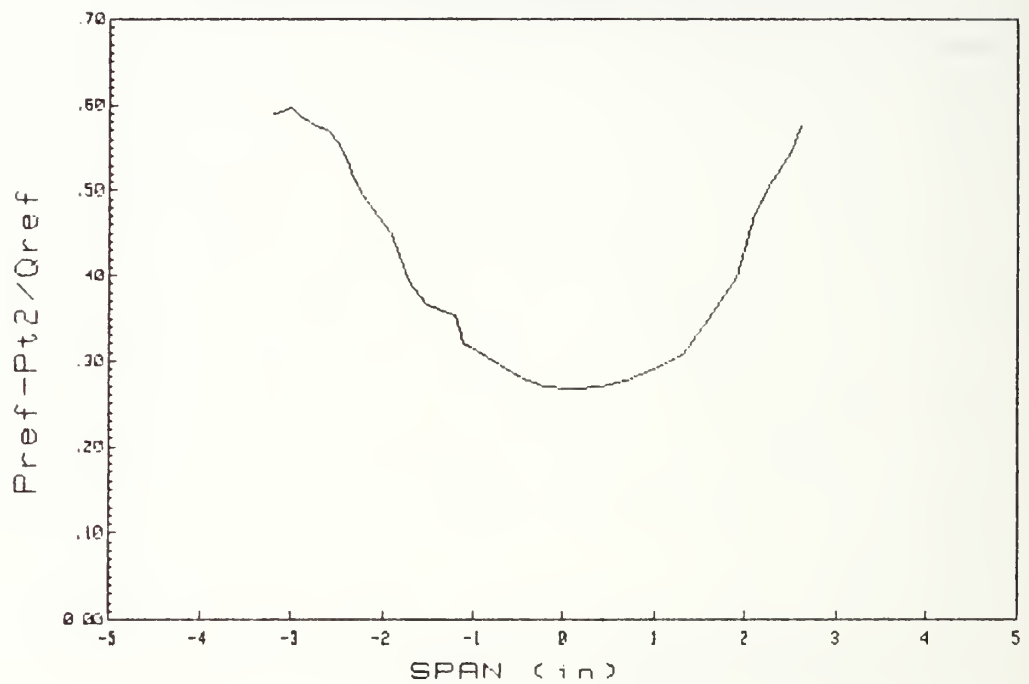


Figure 12. Outlet Survey: Pref-Pt2/Qref vs. Probe Displacement, Spanwise (Pressure Side)

BETA2 VS PROBE DISPLACEMENT

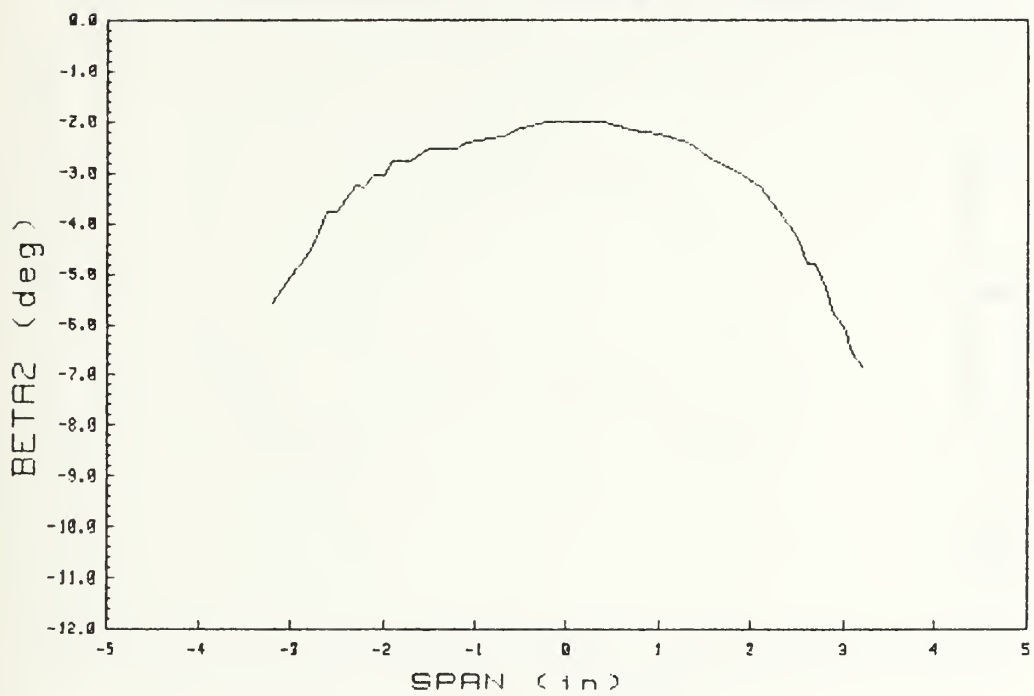


Figure 13. Outlet Survey: Beta2 vs. Probe Displacement, Spanwise (Pressure Side)

V2/Vref VS PROBE DISPLACEMENT

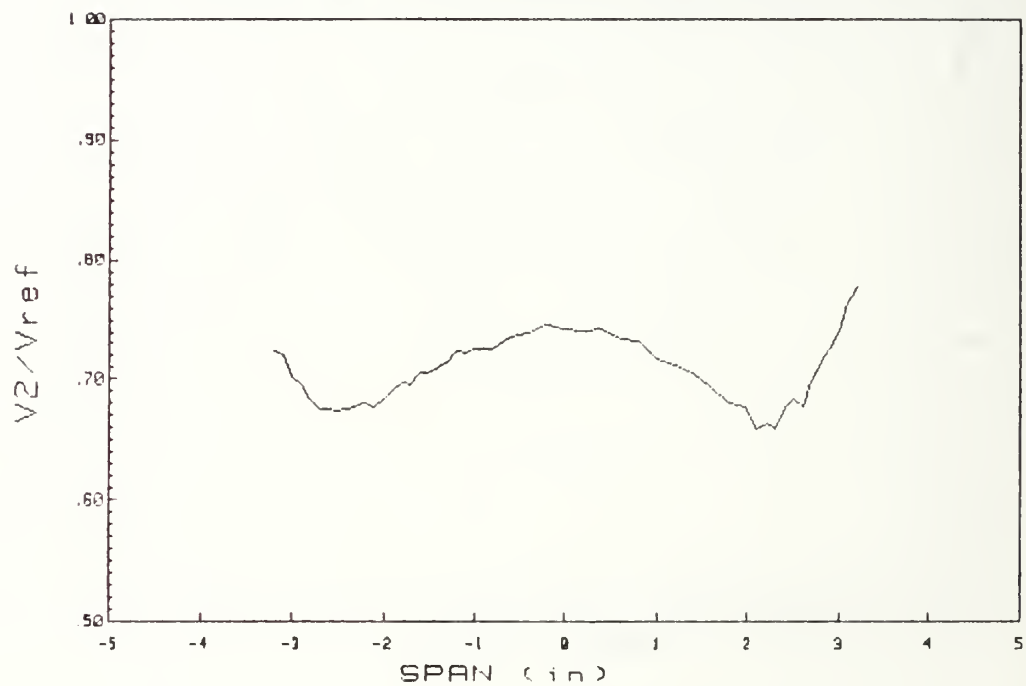


Figure 14. Outlet Survey: $V2/V_{ref}$ vs. Probe Displacement, Spanwise (Suction Side)

Pref-Pt2/Qref VS PROBE DISPLACEMENT

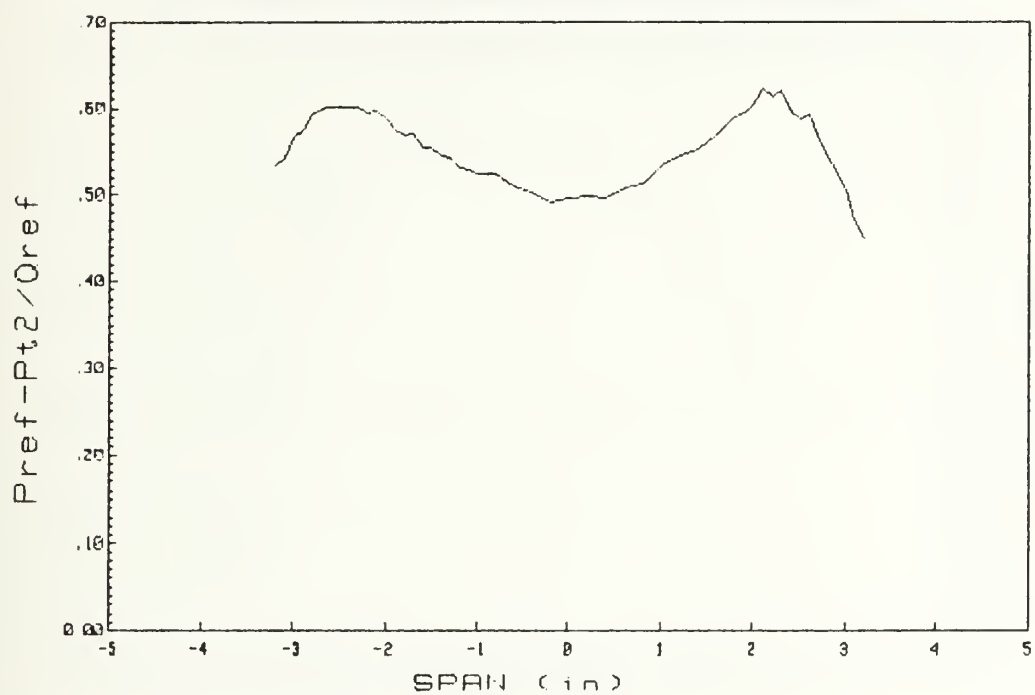


Figure 15. Outlet Survey: Pref-Pt2/Qref vs. Probe Displacement, Spanwise (Suction Side)

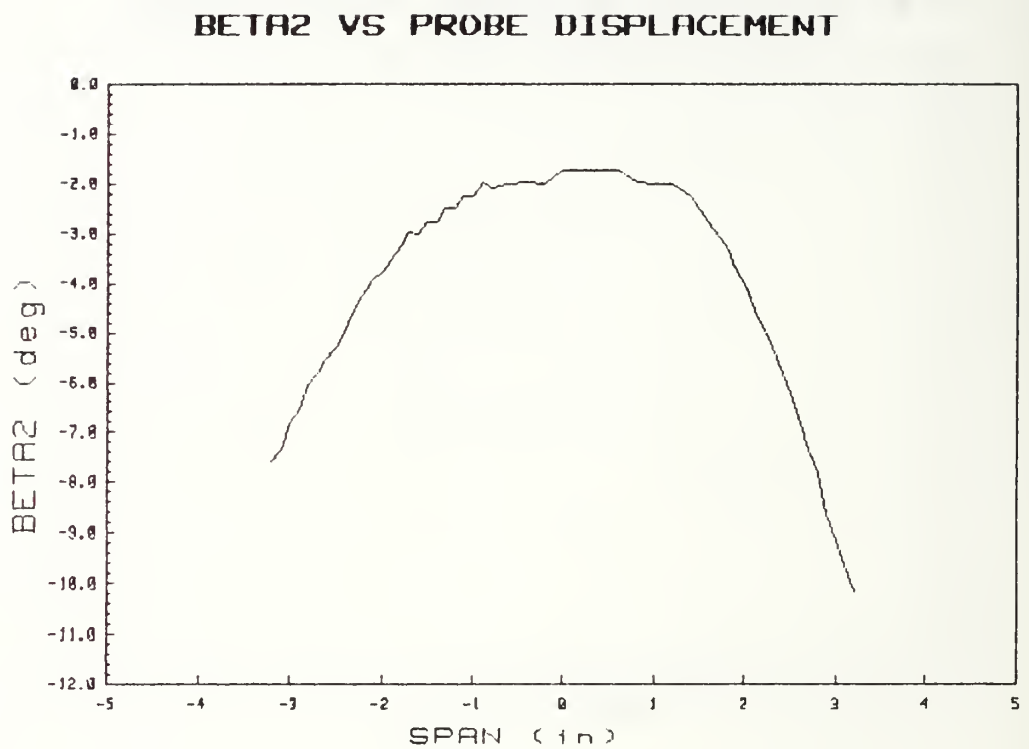


Figure 16. Outlet Survey: Beta2 vs. Probe Displacement Spanwise (Suction Side)

V_1/V_{ref} VS PROBE DISPLACEMENT

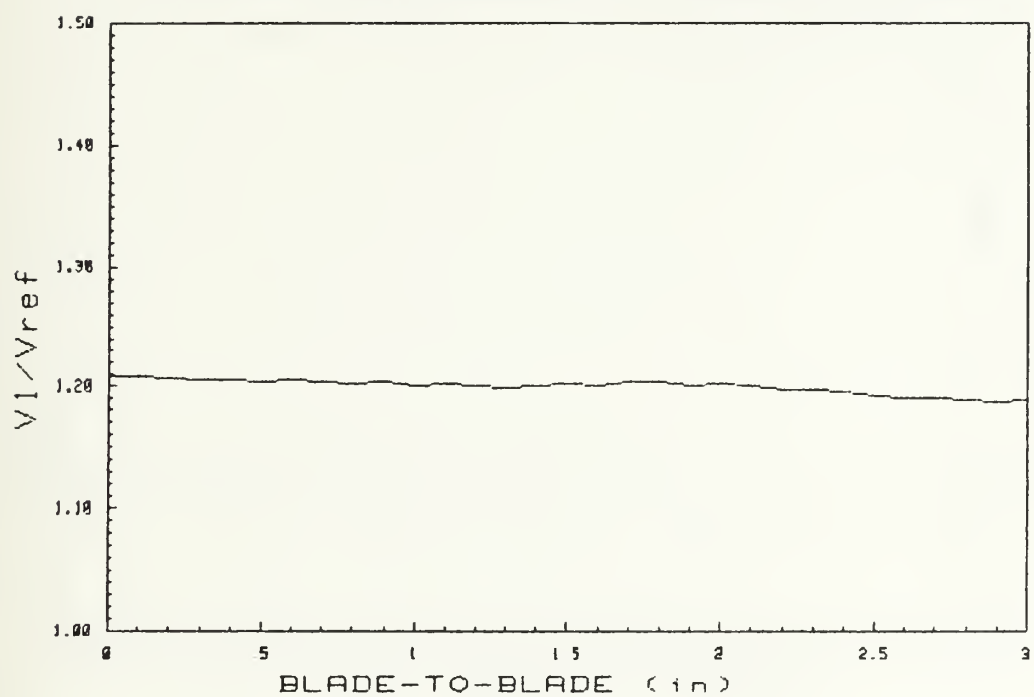


Figure 17. Loss Survey: V_1/V_{ref} vs. Probe Displacement, Blade-to-Blade

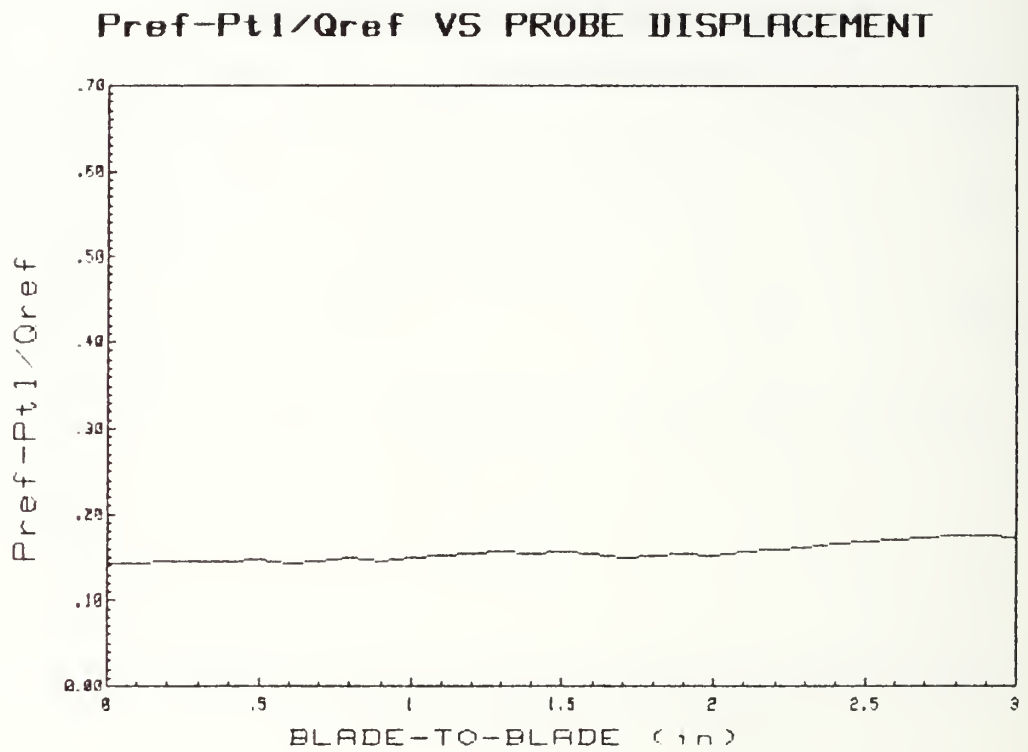


Figure 18. Loss Survey: Pref-Pt1/Qref vs. Probe Displacement, Blade-to-Blade

BETA1 VS PROBE DISPLACEMENT

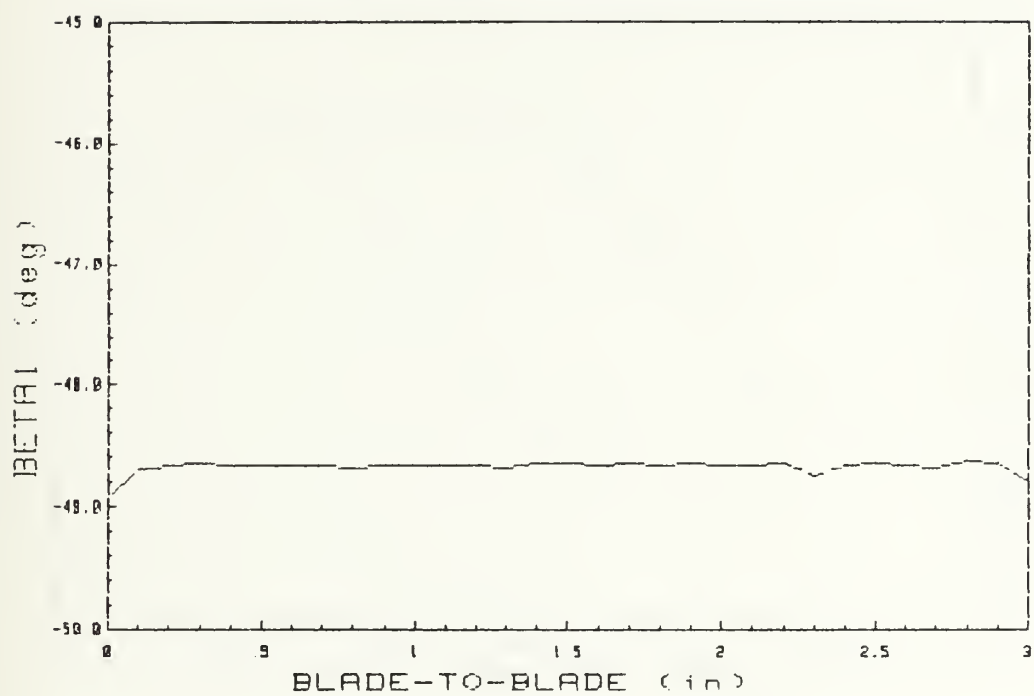


Figure 19. Loss Survey: Beta1 vs. Probe Displacement, Blade-to-Blade

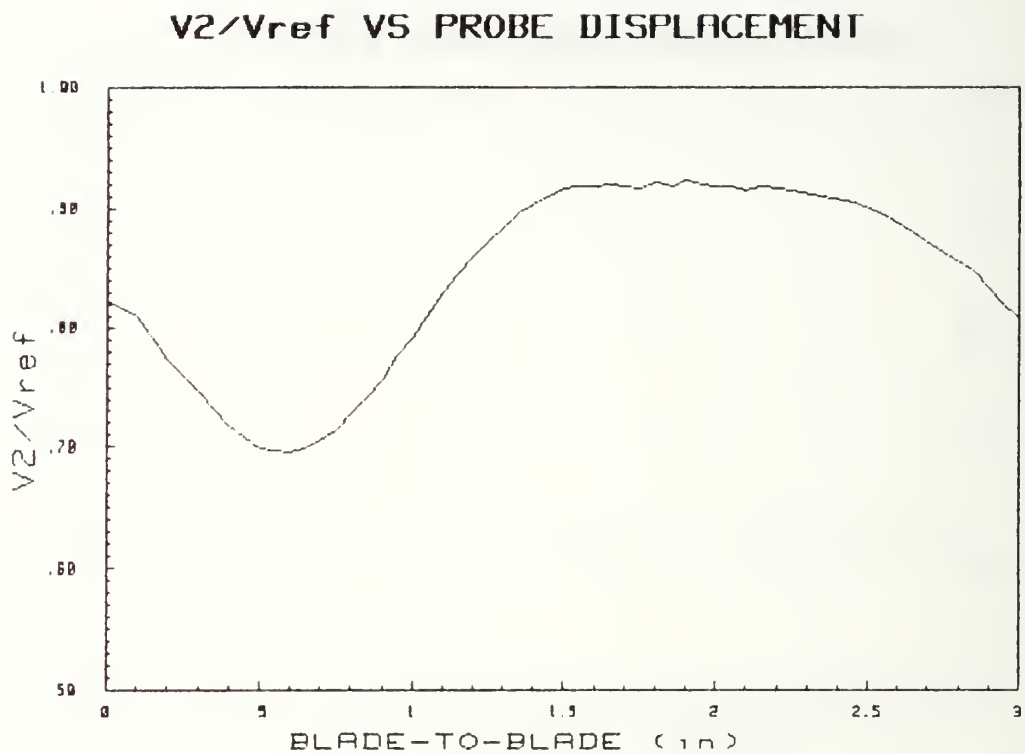


Figure 20. Loss Survey: $V2/V_{ref}$ vs. Probe Displacement, Blade-to-Blade

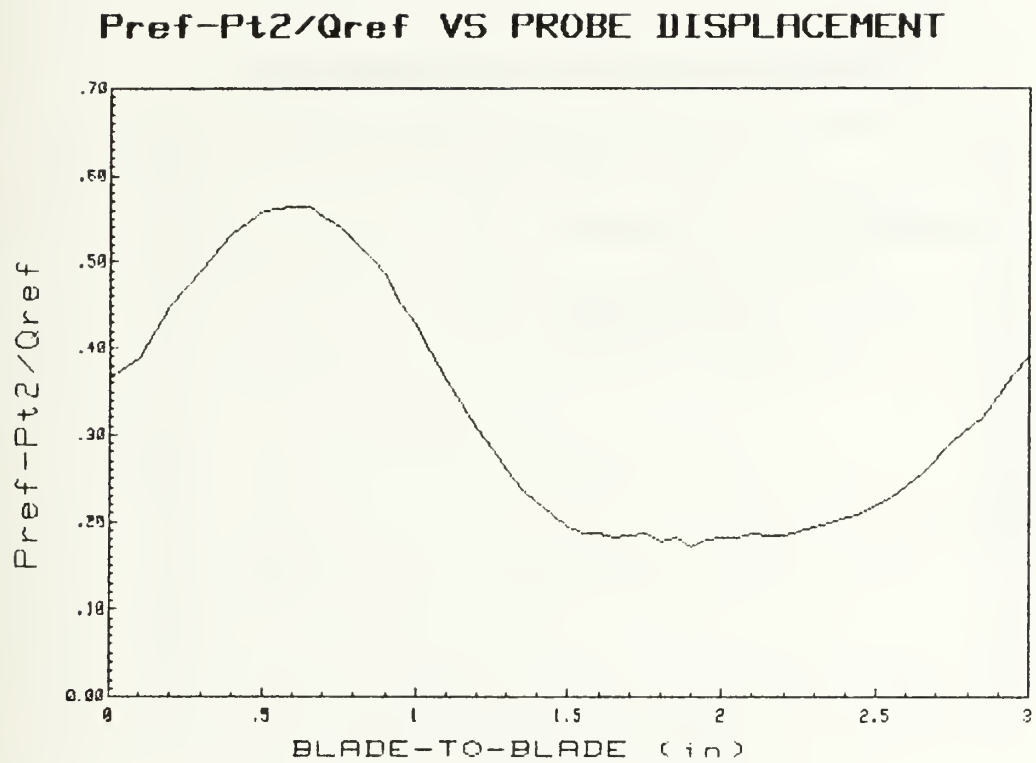


Figure 21. Loss Survey: Pref-Pt2/Qref vs. Probe Displacement, Blade-to-Blade

BETA2 VS PROBE DISPLACEMENT

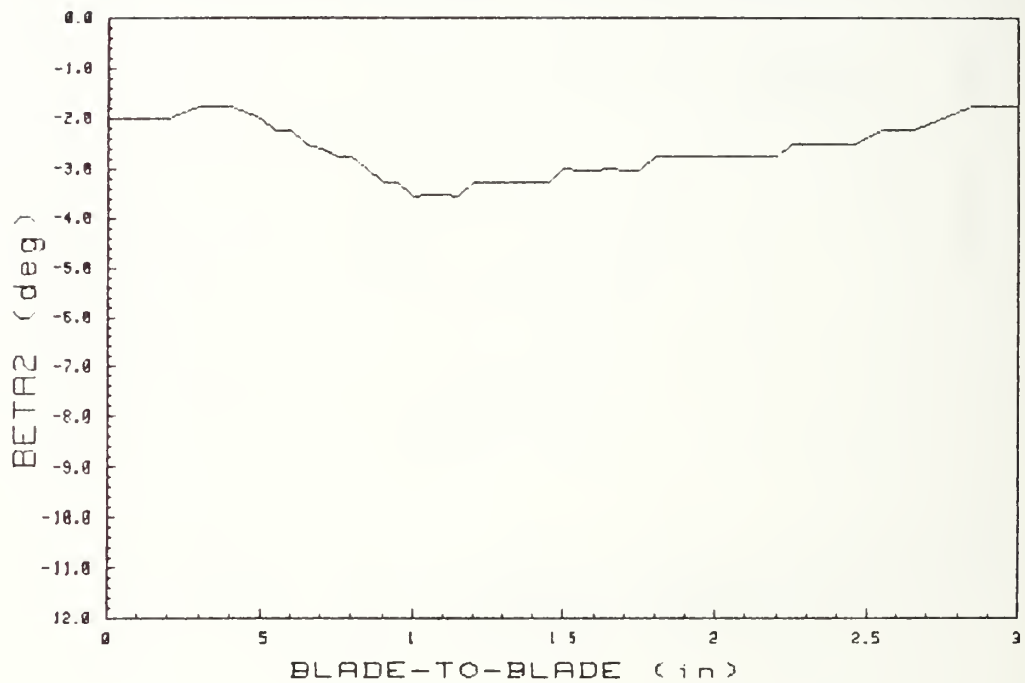


Figure 22. Loss Survey: Beta2 vs. Probe Displacement, Blade-to-Blade

Cp VS PERCENT CHORD

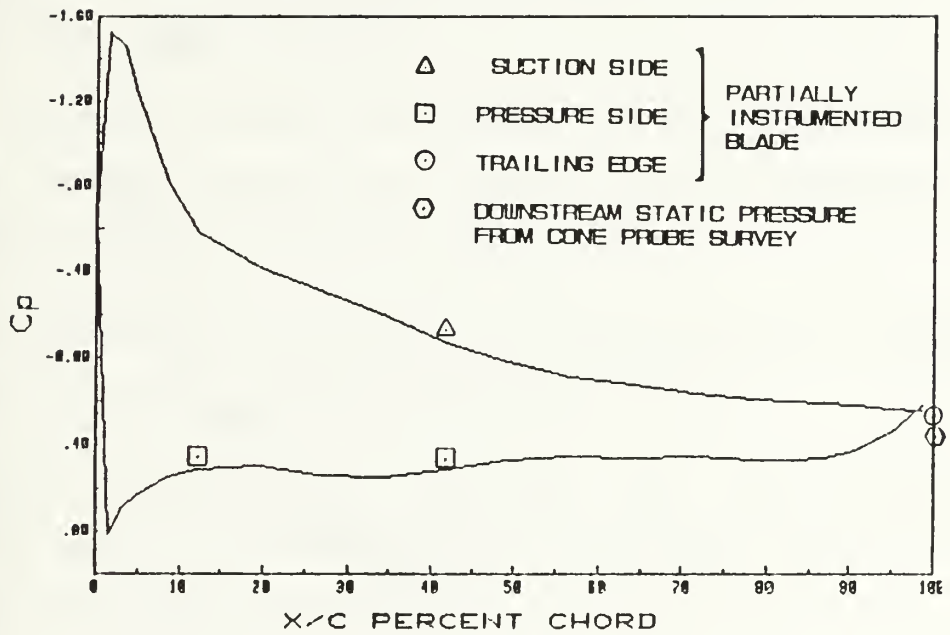


Figure 23. Surface Pressure Distribution:
Cp vs. X/C

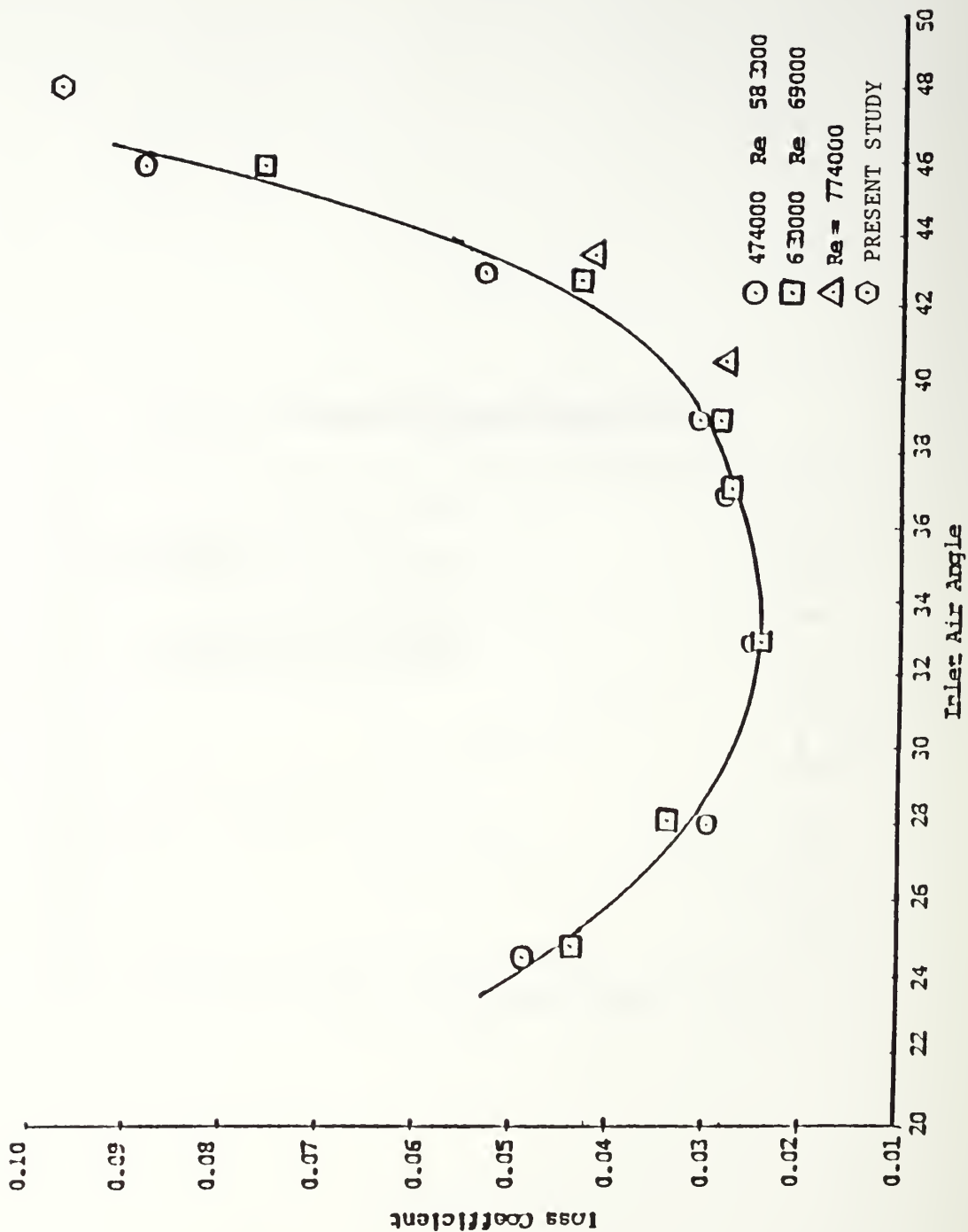


Figure 24. Loss Coefficient vs. Inlet Air Angle

V. CONCLUSIONS AND RECOMMENDATIONS

Preliminary probe surveys were conducted at an inlet flow angle of 48 degrees using data acquisition software specifically written for the Hewlett Packard 300 PC and associated acquisition hardware. From the study, the following conclusions were drawn:

1. At an inlet flow angle of 48 degrees, there was a vanishing core of two-dimensional flow at the downstream survey station.
2. The blade-element performance quantities derived from the measurements were consistent with previous results at lower angle settings.
3. Software for calibrating five-hole pneumatic probes was revalidated and made available for use.
4. New software, for acquiring and reducing probe survey data to obtain the AVDR and loss coefficient, was written and verified.
5. The facility, instrumentation and procedures are available for making accurate off-design loss measurements on a routine basis.

Recommendations focus on improving results which can be obtained using pressure probe surveys in this facility.

(Recommendations concerning the software are given separately in Appendix B.) The recommendations are:

1. Make probe surveys closer to the trailing edge of the blade to reduce the effects of side-wall boundary layer buildup on the two-dimensionality of the flow.
2. Redesign the front wall of the cascade tunnel to be made of lighter materials and of modular construction. The present facility requires a high capacity overhead hoist to remove the wall to modify the cascade geometry. The modular construction would provide the means to expand the coverage of pneumatic and hot-wire probe surveys without sacrificing the quality of the flow through the test section. A design with interchangeable window and survey panels would provide greater access for the LDV.
3. Dreon's [Ref. 4] recommendations concerning calibrating the probe in yaw and automating the probe traverses are reiterated.
4. Incorporate the use of highly accurate linear variable displacement transducers (LVDT) in implementing item 3.
5. Consideration should be given to using two probes simultaneously to conduct the survey (the software has this provision) to avoid the danger of damaging the

probe during transfer to and from the upper and lower traverse slots.

6. Use the LDV system to obtain an accurate probe angle reference as shown in Appendix C.

7. At the present and any higher inlet angle settings, fully map the downstream flow field to better establish flow quality and degree of two-dimensionality.

8. Extend the blade-to-blade surveys to conclusively establish periodicity.

9. Employ the cascade's boundary layer suction provision to extend the range of two-dimensional flow at high inlet flow angles.

APPENDIX A
PROBE CALIBRATION

A1. INTRODUCTION

A five-hole conical probe was calibrated in a 7" free jet facility. The calibration process involved acquiring the data necessary to calculate the probe coefficients, beta and gamma, for various probe pitch angles and free jet flow velocities. Beta and gamma can be shown (Appendix A, Ref. 12) to be functions of Mach number and pitch angle (ϕ) when the probe is balanced (no yaw). The values of beta and gamma over the range of flow velocities and pitch angles tested are, in turn, used to determine a set of probe calibration coefficients for polynomial expressions for Mach number and ϕ in terms of beta and gamma [Ref. 12]. From the polynomial expressions, the Mach number and pitch angle can be determined when the five-hole pneumatic probe is immersed and balanced in an unknown flow.

In the reduction program "CALC" [Appendix B], beta and gamma are calculated from the pressures sensed by the probe. The files containing the probe calibration coefficients are accessed by "CALC" and the coefficients are made available to the subprogram Xphicalc where the non-dimensional velocity X and pitch angle ϕ are calculated. The relation between X , Mach number and other quantities involved in the calculation of the loss coefficient can be seen in Table I.

Section A2 describes the calibration apparatus. The calibration test program is addressed in Section A3. Results and discussion in Section A4 are followed by Recommendations in Section A5. Tables of data produced during the calibration of the cone probe used in the present study are contained in Section A6.

The following is a list of symbols used in Appendix A:

PA	Atmospheric Pressure
PK	Total pressure as sensed by the Kiel probe.
P1 - P5	Probe pressure parts as shown in Fig. A2.
P23	$(P2 + P3)/2$

A2. PROBE CALIBRATION APPARATUS

A2.1 Hardware

An illustration of the probe calibration apparatus and picture of the probe are shown in Fig. A1 and Fig. A2 respectively. The probe port numbering is also shown in Fig. A2. The 7 inch diameter free jet receives air from the Allis Chalmers compressor. Flow rate is controlled by a hand operated valve near the free jet attachment to the settling chamber. Honeycomb flow straighteners remove swirl and the nozzle acceleration generates a nearly uniform velocity profile at the probe.

A United Sensor 5-hole conical probe, #DC-125-24-F-22-065-4" was mounted vertically on top of the free jet frame. A special mount allowed the probe to be yawed, pitched and translated i.e., the immersion distance

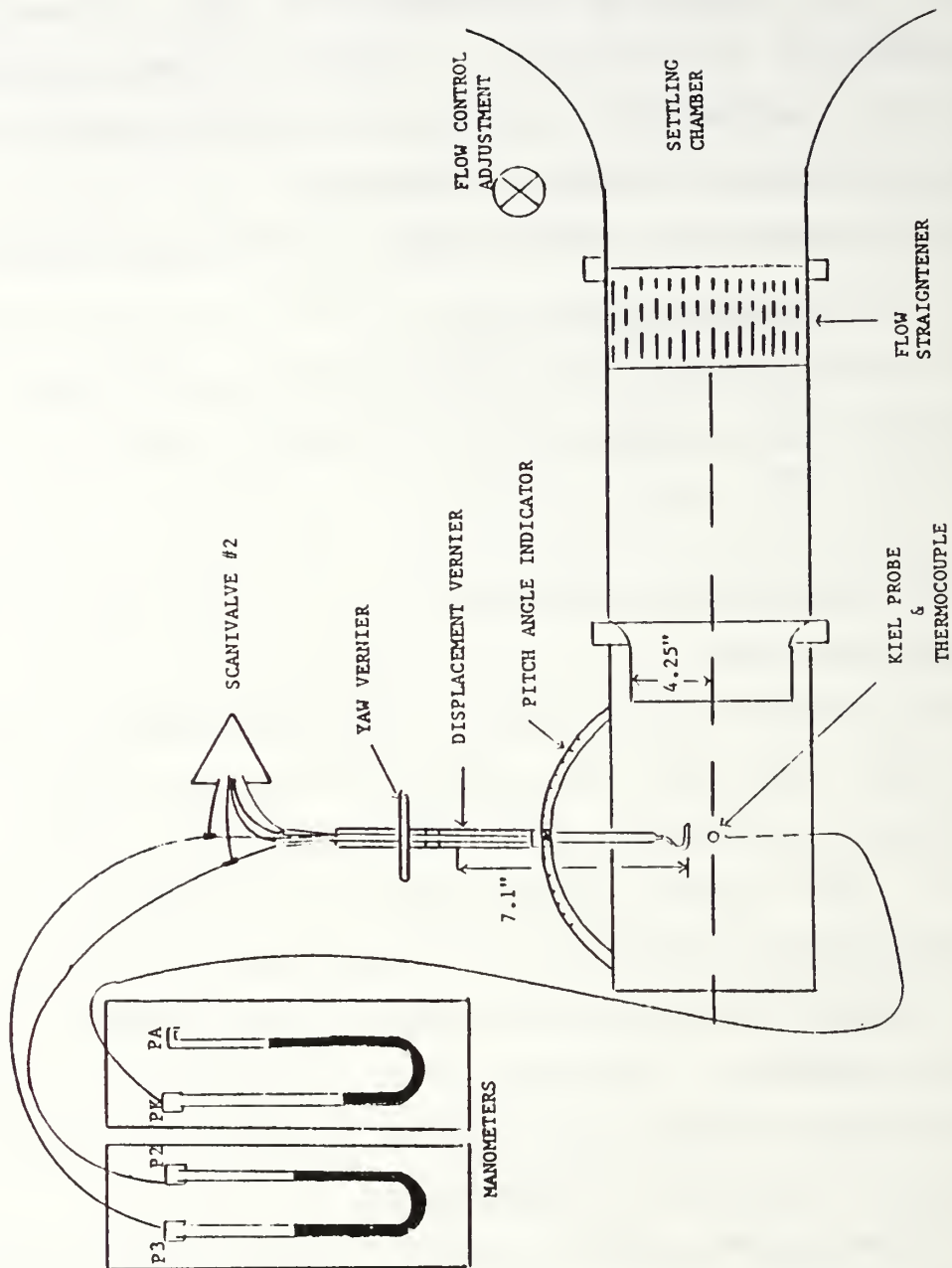


Figure A1. Probe Calibration Apparatus

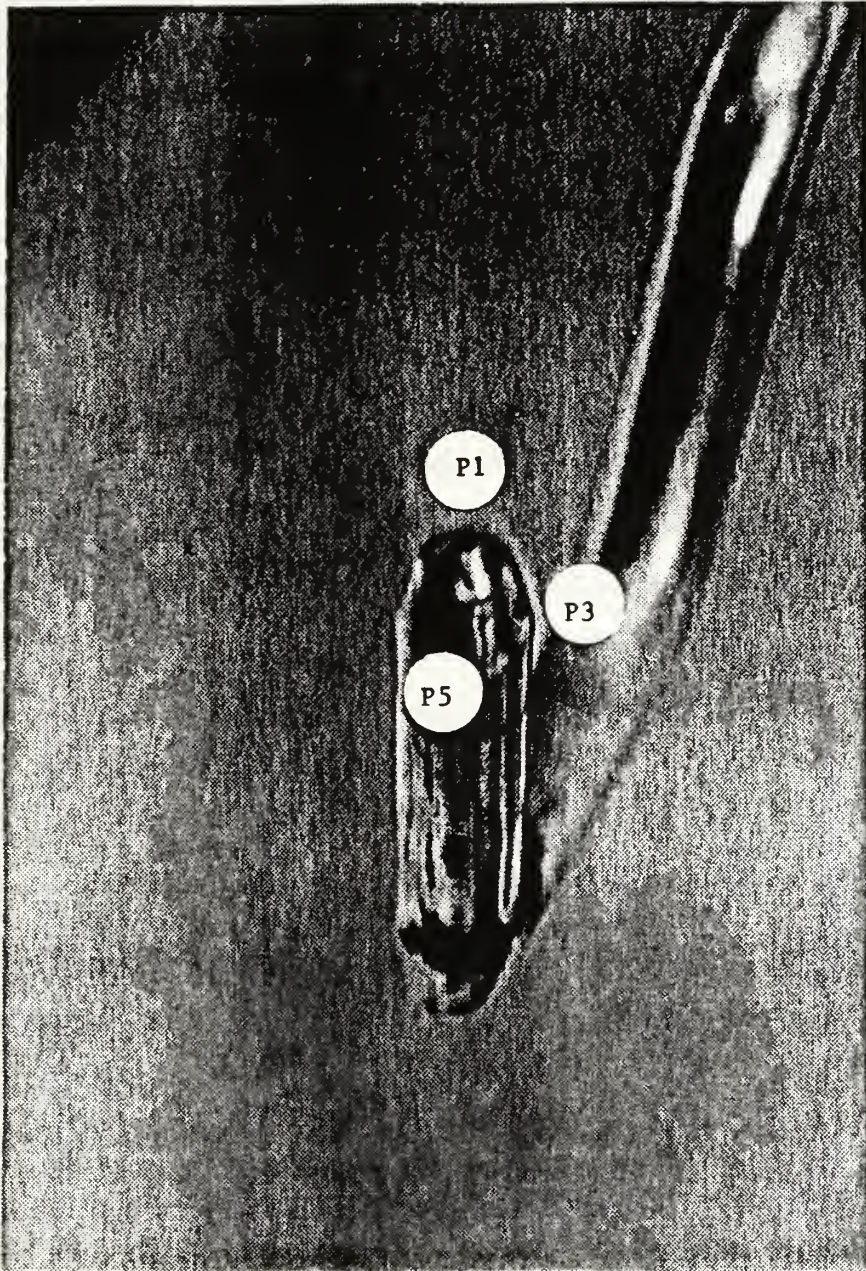


Figure A2. Five-Hole Conical Probe

could be varied. In this case, the immersion distance was fixed to read 7.1 on the vernier, allowing the probe to be rotated about its tip.

A combination Kiel and thermocouple probe was mounted horizontally and positioned into the flow to read total pressure and temperature.

Two water manometers were mounted next to the free jet. Pressures from conical probe ports 2 & 3 were fed to each side of one manometer, thus allowing the probe to be balanced in yaw. Total pressure as sensed by the Kiel probe (PK) was fed to the other manometer to allow the total flow of the free jet to be adjusted and monitored.

A Scanivalve rated at 2.5 psid sampled the conical probe pressures in addition to the Kiel probe and atmospheric pressures. A scanner, Scanivalve controller, and digital voltmeter (DVM) were used in conjunction with the Scanivalve to convert the pressures to digital form for subsequent storage and reduction.

Data acquisition software was run on the Hewlett Packard 9830 computer and associated peripheral components. The HP 9830 system primarily was used to record, store, and reduce the Scanivalve and thermocouple output while the HP 21MX system performed the calculations to generate the probe calibration coefficients.

A2.2 Software

The primary acquisition program was PRBCAL. Entries consisted of atmospheric pressure in inches Hg, number of

separate probe pitch angles (maximum of 12), Scanivalve number, temperature channel and number of samples to average (normally five). The program acquired the data for each probe pitch setting, then stopped to allow the user to change the pitch setting and balance the probe before data was again acquired. After all pitch settings had been sampled, the program prompted the user for a six element alphanumeric file name for the data to be stored. This file had to be opened prior to running PRBCAL. After the file name was entered in response to the prompt, the reduced data was printed in the form of Tables A1 - A3.

The program PRBRED generated probe coefficients and other parameters from the PRBCAL data files. PRBRED, used in conjunction with the "KEY" program PLOTK, allowed probe coefficients to be plotted against pitch angles. The PLOTK program required some familiarity with Hewlett Packard plotting procedures.

CALI2 provided the means to transfer data files from the HP 9830 system to the HP 21MX system. This was required since the 9830 system does not have the capability to generate the calibration coefficients. PRBCAL, PRBRED, PLOTK & CALI2 were on disc SHREEVE P007.

A data transfer program, also named CALI2, was loaded and run on the HP 21MX when CALI2 was run on the HP 9830. The raw data files were transferred and probe calibration quantities were calculated by the HP 21MX programs as shown in Tables A4 and A5. The program JOHN3 combined the

TABLE A1. TABULATED SCALED DATA OUTPUT BY
PRBCAL (DATAFILES CV = 100; CV = 150)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
-0.0040	34.518 **	2.4020	-0.1630	0.2420	-0.4740	2.336 **	-6.0
-0.0240	34.468 **	2.4120	-0.1430	0.1180	-0.3980	2.340 **	-4.0
-0.0400	-0.048 **	2.3260	-0.1270	0.0820	-0.3580	2.316 **	-3.0
-0.0240	-0.030 **	2.3370	-0.1270	0.0540	-0.3180	2.354 **	-2.0
-0.0520	-0.044 **	2.3130	-0.1180	0.0120	-0.2500	2.326 **	-1.0
-0.0360	-0.036 **	2.3020	-0.1240	-0.0320	-0.2180	2.342 **	0.0
-0.0440	-0.058 **	2.2780	-0.1380	-0.1260	-0.1980	2.306	1.0
-0.0500	-0.020 **	2.3280	-0.1160	-0.1140	-0.1220	2.338	2.0
-0.0340	-0.054 **	2.2980	-0.1270	-0.1720	-0.0980	2.318 *	3.0
-0.0480	-0.050 **	2.3180	-0.1290	-0.2300	-0.0260	2.320 **	4.0
-0.0420	-0.046 **	2.2960	-0.1100	-0.2560	0.0200	2.344 *	6.0

ATMOS. PRESS. (IN.HG) TEMPERATURE (F)

30.06	98.61
30.06	99.43
30.06	100.07
30.06	100.58
30.06	100.92
30.06	101.29
30.06	101.32
30.06	101.60
30.06	101.76
30.06	101.93
30.06	102.27

DATA STORED IN CV=100

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.0540	32.900 **	5.3300	-0.3430	0.5460	-1.0200	5.326 **	-6.0
0.0200	32.924 **	5.3360	-0.3010	0.3300	-0.8540	5.284 **	-4.0
0.0260	-0.032 **	5.2540	-0.2820	0.1760	-0.8115	5.292 **	-3.0
-0.0260	-0.012 **	5.2580	-0.2680	0.1040	-0.6980	5.320 **	-2.0
-0.0040	-0.010 **	5.2560	-0.2680	0.0100	-0.6220	5.292 **	-1.0
-0.0360	-0.028 **	5.2520	-0.2480	-0.0820	-0.5320	5.306 **	0.0
-0.0600	-0.072 **	5.2940	-0.2330	-0.1640	-0.4160	5.314 **	1.0
-0.0640	-0.066 **	5.2740	-0.2270	-0.2380	-0.2920	5.338 **	2.0
-0.0900	-0.086 **	5.2940	-0.2120	-0.3200	-0.1940	5.346 **	3.0
-0.0740	-0.064 **	5.2260	-0.2410	-0.4380	-0.1140	5.276 **	4.0
-0.1000	-0.098 **	5.2560	-0.2630	-0.6000	0.1060	5.332 *	6.0

ATMOS. PRESS. (IN.HG) TEMPERATURE (F)

30.09	109.50
30.09	109.70
30.09	109.70
30.09	109.73
30.09	109.70
30.09	109.77
30.09	109.70
30.09	109.77
30.09	109.80
30.09	109.77
30.09	109.84

DATA STORED IN CV=150

TABLE A2. TABULATED SCALED DATA OUTPUT BY
PRBCAL (DATA FILES CV = 200, CV = 250)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.0100	0.014 **	9.1660	-0.6360	0.9560	-1.8500	9.350 **	-6.0
-0.0160	-0.014 **	9.2660	-0.5700	0.5680	-1.5600	9.364 **	-4.0
-0.0520	-0.062 **	9.2540	-0.5410	0.3980	-1.4320	9.348 **	-3.0
-0.0700	-0.070 **	9.3000	-0.5010	0.1730	-1.2740	9.380 **	-2.0
-0.0400	-0.030 **	9.3100	-0.4610	0.0500	-1.0940	9.372 **	-1.0
-0.0160	-0.020 **	9.3000	-0.4860	-0.3420	-0.7820	9.352 **	1.0
-0.0200	-0.024 **	9.2560	-0.4690	-0.4860	-0.6080	9.344 **	2.0
-0.0380	-0.044 **	9.2840	-0.4530	-0.6240	-0.4380	9.364 **	3.0
-0.0320	-0.032 **	9.2140	-0.4670	-0.7720	-0.2440	9.326 **	4.0
-0.0300	-0.024 **	9.2360	-0.5190	-1.1000	0.1280	9.334 **	6.0

ATMOS. PRESS. (IN.HG) TEMPERATURE (F)

30.10	108.45
30.10	108.38
30.10	108.24
30.10	108.34
30.10	108.55
30.10	108.75
30.10	108.72
30.10	108.72
30.10	108.75
30.10	108.85
30.10	108.99

DATA STORED IN CV=200

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES (IN.H2O)

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.1040	32.980 **	14.4320	-1.1430	1.1300	-3.1100	14.550 **	-6.0
-0.3400	32.978 **	14.6340	-0.8610	0.8380	-2.5020	14.658 **	-4.0
-0.0460	32.970 **	14.5880	-0.8090	0.6160	-2.2320	14.660 **	-3.0
-0.0460	32.984 **	14.7120	-0.7780	0.3180	-1.9940	14.688 **	-2.0
-0.0140	32.648 **	14.6840	-0.7630	0.0380	-1.7480	14.644 **	-1.0
-0.0320	-0.024 **	14.6080	-0.7250	-0.2260	-1.4880	14.764 **	0.0
-0.0620	-0.050 **	14.6960	-0.6750	-0.4500	-1.2160	14.782 **	1.0
-0.2620	-0.258 **	14.7620	-0.4910	-0.4980	-0.7800	14.880 **	2.0
-0.0480	-0.050 **	14.5180	-0.7320	-1.0340	-0.7520	14.622 **	3.0
-0.0720	-0.060 **	14.5300	-0.7760	-1.2980	-0.4720	14.684 **	4.0
-0.0580	-0.056 **	14.6380	-0.8880	-1.9160	0.0960	14.750 **	6.0

ATMOS. PRESS. (IN.HG) TEMPERATURE (F)

30.11	107.26
30.11	107.12
30.11	107.12
30.11	107.12
30.11	107.09
30.11	107.19
30.11	107.26
30.11	107.26
30.11	107.29
30.11	107.16
30.11	107.33

DATA STORED IN CV=250

TABLE A3. TABULATED SCALED DATA OUTPUT BY
PRBCAL (DATA FILES CV = 300)

RAW DATA WITH VOLTAGE CORRECTED TO PRESSURES<IN.H2O>

PA-PA	PCAL-PA**	P1-PA	P23-PA	P4-PA	P5-PA	PK-PA **	PHI
0.0320	30.956 **	21.1960	-1.5050	2.2300	-4.3800	21.458 **	-6.0
-0.0080	30.188 **	21.3360	-1.2700	1.3200	-3.6400	21.480 **	-4.0
-0.0140	29.022 **	21.4420	-1.1880	0.9380	-3.3260	21.524 **	-3.0
0.0040	28.518 **	21.5880	-1.1510	0.4780	-2.9640	21.612 **	-2.0
-0.0280	27.730 **	21.4020	-1.1010	0.1000	-2.5800	21.448 **	-1.0
0.0040	27.048 **	21.3080	-1.0380	-0.2920	-2.2020	21.334 **	0.0
-0.0120	26.554 **	21.3020	-1.0220	-0.7100	-1.7840	21.352 **	1.0
-0.0260	25.724 **	21.3680	-1.0270	-1.1540	-1.4600	21.538 **	2.0
-0.0480	25.240 **	21.5420	-1.0680	-1.5440	-1.0620	21.664 **	3.0
-0.0160	24.756 **	21.4160	-1.1220	-1.9800	-0.6700	21.542 **	4.0
-0.0040	24.156 **	21.4520	-1.3430	-2.1100	0.1400	21.656 **	6.0

ATMOS. PRESS. (IN.HG)	TEMPERATURE (F)
30.12	107.50
30.12	107.56
30.12	107.50
30.12	107.36
30.12	107.46
30.12	107.70
30.12	107.80
30.12	107.80
30.12	107.77
30.12	107.77
30.12	107.80

DATA STORED IN CV=300

TABLE A4. TABULATED REDUCED DATA OUTPUT BY CALI2
(DATA FILES CV = 100, CV = 150, CV = 200)

THE DATA FROM DATA SET # 1 OF FILE CV=100 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.006250	.279142	.001745	.040063	.089655	-6.000000	58.611176
.006225	.201257	.001257	.040269	.090118	-4.000000	99.425010
.005978	.179372	.001072	.040458	.090541	-3.000000	100.069310
.006007	.150813	.000907	.040387	.090383	-2.000000	100.578000
.005936	.107553	.000638	.040322	.090393	-1.000000	100.917100
.005913	.076669	.000453	.040390	.090382	0.000000	101.270100
.005888	.029801	.000175	.040154	.089858	1.000000	101.324010
.005956	.003273	.000019	.040476	.090581	2.000000	101.595310
.005910	-.030515	-.000180	.040168	.089892	3.000000	101.764800
.005963	-.083367	-.000497	.040306	.090201	4.000000	101.934600
.005864	-.114713	-.000673	.040458	.090541	6.000000	102.273500

THE DATA FROM DATA SET # 1 OF FILE CV=150 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.013711	.276044	.003785	.060780	.136127	-6.000000	109.496310
.013625	.210041	.002862	.060359	.135212	-4.000000	109.699800
.013303	.178380	.002387	.060438	.135390	-3.000000	109.699900
.013359	.145132	.001939	.060595	.135744	-2.000000	109.733700
.013355	.114410	.001528	.060312	.135108	-1.000000	109.699900
.013296	.081818	.001088	.060573	.135696	0.000000	109.767590
.013359	.045594	.000609	.060754	.136102	1.000000	109.699800
.013296	.009816	.000131	.060911	.136455	2.000000	109.767590
.013307	-.022884	-.000305	.061103	.136805	3.000000	109.801500
.013215	-.059265	-.000783	.060620	.135799	4.000000	109.767590
.013339	-.127922	-.001706	.061080	.136835	6.000000	109.835400

THE DATA FROM DATA SET # 1 OF FILE CV=200 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.023468	.286268	.006718	.079903	.179242	-6.000000	108.445100
.023542	.216348	.005093	.080072	.179624	-4.000000	108.377300
.023443	.186030	.004380	.080158	.179817	-3.000000	108.241520
.023454	.146108	.003427	.080369	.180293	-2.000000	108.343400
.023383	.117081	.002738	.080208	.179931	-1.000000	108.546800
.023097	.078980	.001824	.079624	.178612	0.000000	108.750310
.023421	.044962	.001053	.080022	.179511	1.000000	108.716400
.023277	.012545	.000292	.080005	.179472	2.000000	108.716400
.023303	-.019102	-.000445	.080166	.179835	3.000000	108.750310
.023173	-.054540	-.001264	.079981	.179417	4.000000	108.852010
.023349	-.125881	-.002939	.080006	.179474	6.000000	108.987520

TABLE A5. TABULATED REDUCED DATA OUTPUT BY CALI2
(DATA FILES CV = 250, CV = 300)

THE DATA FROM DATA SET # 1 OF FILE CV=250 ARE

Beta	Gamma	Delta	X vel	Machno.	Phi	T Tunnel
.036822	.272231	.010024	.090082	.222196	-6.000000	107.250190
.036603	.219426	.008032	.099707	.224068	-4.000000	107.122600
.036375	.184971	.006728	.099734	.224129	-3.000000	107.122600
.036501	.149258	.005460	.099026	.224339	-2.000000	107.122600
.036487	.115621	.004219	.092573	.223764	-1.000000	107.088700
.036223	.082306	.002981	.100031	.224804	0.000000	107.190400
.036303	.049444	.001795	.100191	.225166	1.000000	107.258190
.036001	.018488	.000666	.101176	.227402	2.000000	107.258190
.036034	-.018492	-.000666	.099507	.223796	3.000000	107.252100
.036163	-.053966	-.001952	.099900	.224507	4.000000	107.156490
.036674	-.129589	-.004753	.100071	.224896	6.000000	107.326100

THE DATA FROM DATA SET # 1 OF FILE CV=300 ARE

.052799	.294177	.015374	.120303	.270974	-6.000000	
.052556	.219411	.011531	.120471	.271359	-4.000000	107.563400
.052598	.189422	.009911	.120607	.271668	-3.000000	107.495610
.052836	.151370	.007998	.120796	.272101	-2.000000	107.360000
.052306	.119095	.006229	.120439	.271204	-1.000000	107.461700
.051956	.085474	.004441	.120042	.270377	0.000000	107.699100
.051904	.048110	.002497	.120135	.270589	1.000000	107.800900
.052059	.013664	.000711	.120670	.271830	2.000000	107.800900
.052535	-.021318	-.001120	.121078	.272744	3.000000	107.766210
.052387	-.058390	-.003059	.120661	.271793	4.000000	107.766210
.052981	-.142575	-.007554	.120937	.272423	6.000000	107.800900

separate files generated during CALI2 execution into a single file consistent with the format required for the JOHN4 program. (A tabulation of JOHN3 data is not included since the quantities are the same as those listed in the separate files of CALI2.) JOHN4 produced a surface plot of the data (Figs. A3 and A4) and generated a matrix of the probe calibration coefficients (Table A6). Figures A3 and A4 are plots of the actual data generated from the probe calibration process, while the ERRORS (%) at each point in Table A6 quantitatively show the difference between the data points in Figures A3 and A4 and the "best fit" surface at the given values of beta and gamma. The "best fit" surface was given by the polynomial expressions previously cited [Ref. 12] using the matrix of calibration coefficients produced by JOHN4, and tabulated in Table A6. JOHN4 produced a matrix of coefficients and also associated tabulation of errors at each point for increasingly higher order polynomials. The user was required to make the choice of what order polynomial gave the best fit to the actual data by an examination of the errors at each point, associated with the use of polynomials of different orders. It is noted that the program prompts the user for the M and N order of the "best fit" polynomial. The coefficients are presented in an M by N matrix where M represents column values and N represents row values. The polynomial order entered is thus, M-1 and N-1, since the polynomial order is one less than the number of coefficients that it requires.

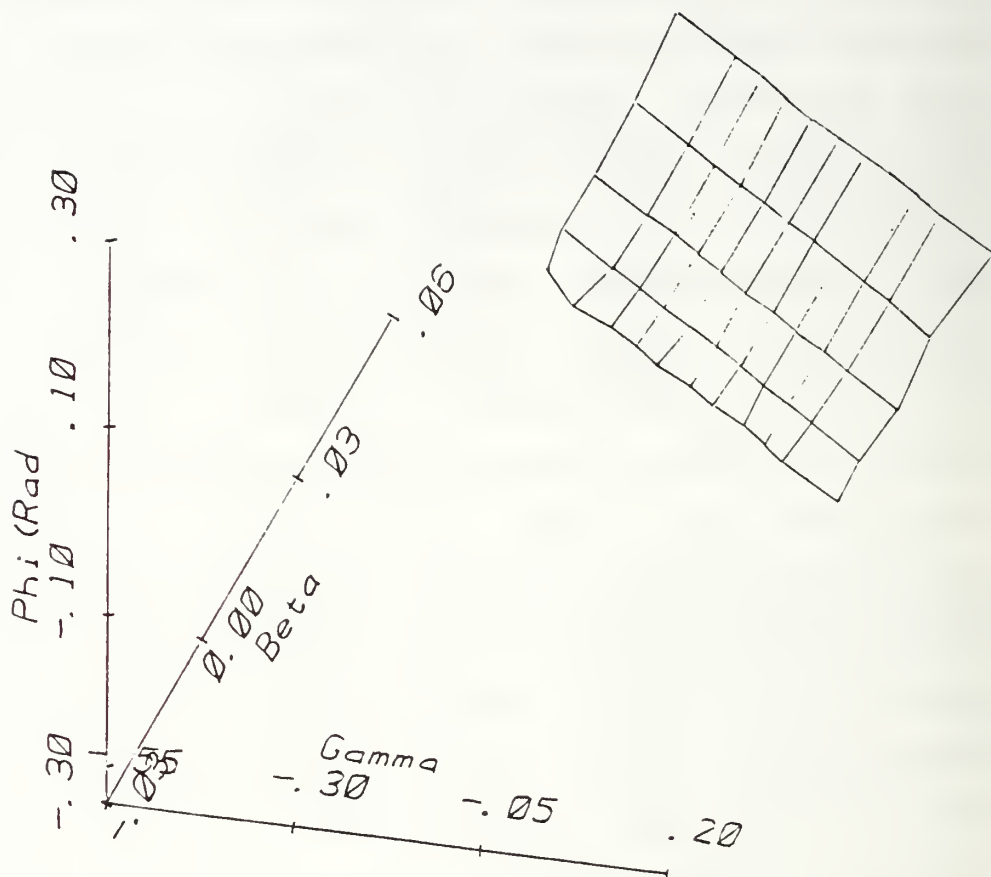


Figure A3. Surface Plot of Φ . vs. Γ and β

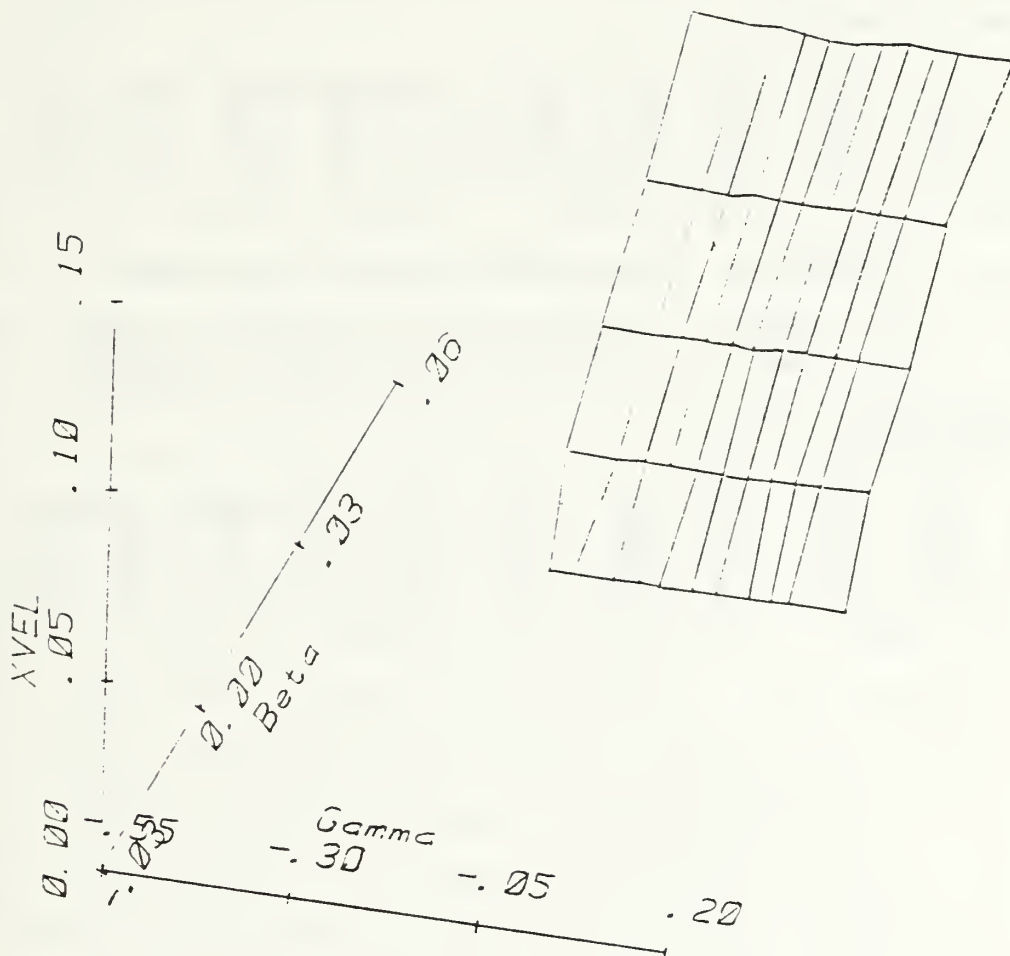


Figure A4. Surface Plot of X (velocity)
vs. Gamma and Beta

TABLE A6. BEST FIT CALIBRATION COEFFICIENTS
SELECTED USING JOHN4 WITH ASSOCIATED
ERRORS

COEFFICIENTS FOR THE CALIBRATION SURFACE STORED IN FILE MIKEC3

	1	2	3	4	5
1	.015926	4.932133	-153.668740	3137.961400	-24299.0050
2	-.007563	.699505	-62.977261	2068.372100	-20872.1480
3	.088898	-24.844173	1988.495400	-57799.7030	541835.5000
	1	2	3	4	5

ERRORS(1) AT EACH POINT

	1	2	3	4	5	6	7	8	9	10	11
1	-.556	-1.098	1.832	.319	.522	.499	-.135	-.007	-.467	-.595	.644
2	1.001	-.463	.161	.114	-.650	-.257	-.411	-.051	.173	-.252	.300
3	-.418	-.264	.076	.329	.273	.118	-.092	.137	.225	.101	-.359
4	.137	.325	.198	-.392	-.785	-.114	-.180	1.225	-.346	-.005	-.024
5	-.064	.139	.092	-.050	-.027	-.212	-.172	.166	.233	.026	-.087
	1	2	3	4	5	6	7	8	9	10	11

COEFFICIENTS FOR THE CALIBRATION SURFACE STORED IN FILE MIKEC2

	1	2	3	4	5
1	.023535	3.178730	-199.593070	5134.302700	-45091.8900
2	-.557400	11.194368	-778.272950	21622.69100	-188556.340
3	.758150	-183.145780	12999.86900	-351917.690	3136813.000
	1	2	3	4	5

ERRORS(DEGREES) AT EACH POINT

	1	2	3	4	5	6	7	8	9	10	11
1	-.071	-.258	.097	.288	.049	.158	-.205	.010	.013	-.569	.486
2	.084	-.017	-.004	-.032	.030	.049	-.028	-.075	-.018	-.051	.041
3	-.049	-.056	.094	-.083	.075	-.034	-.026	.025	.096	.053	-.056
4	-.079	.176	.071	-.047	-.080	-.078	-.050	.059	.006	.016	-.008
5	.060	-.054	.019	-.069	-.000	.008	-.053	.006	.097	.102	-.084
	1	2	3	4	5	6	7	8	9	10	

A3. TEST PROGRAM AND RESULTS

The calibration was conducted at five flow velocities: nominally 100, 150, 200, 250 and 300 ft/sec. At each velocity, the probe was moved to -6, -4, -3, -2, -1, 0, 1, 2, 3, 4, 6 degrees of pitch (ϕ) and balanced so probe port P2 and P3 pressures were equal on the manometer. The data were stored in files CV=100 to CV=300 on disc SHREEVE P007.

Prior to the calibration, a survey of the free jet was conducted at a flow of approximately 200 ft/sec to determine the velocity profile. The survey was conducted from top to bottom and, with the probe mounted on the underside, from bottom to top. There was some overlap in the survey, which in principle, would allow the departure of the jet flow direction from true axial to be resolved by the pitch angle indicated from the two sides.

Data collected in files CV=100, CV=200 and CV=300 and subsequently reduced by PRBRED were handplotted to show the effect of pitch angle on the coefficients. Fig. A5 shows ϕ vs. β , where $\beta = (P1-P23)/P1$. Fig. A6 is a plot of ϕ vs. $\bar{\beta}$, where $\bar{\beta} = \beta/(PK-PA)/PK$. ϕ vs γ ($P1-P4/P1-P23$) is shown in Fig. A7 and ϕ vs. $(P1-PK)/(PK-PA)$ is plotted in Fig. A8. Free jet survey results are shown in Fig. A9.

A4. DISCUSSION

The probe calibration data presented in Figs. A3-A9 are well-behaved and qualitatively consistent with the

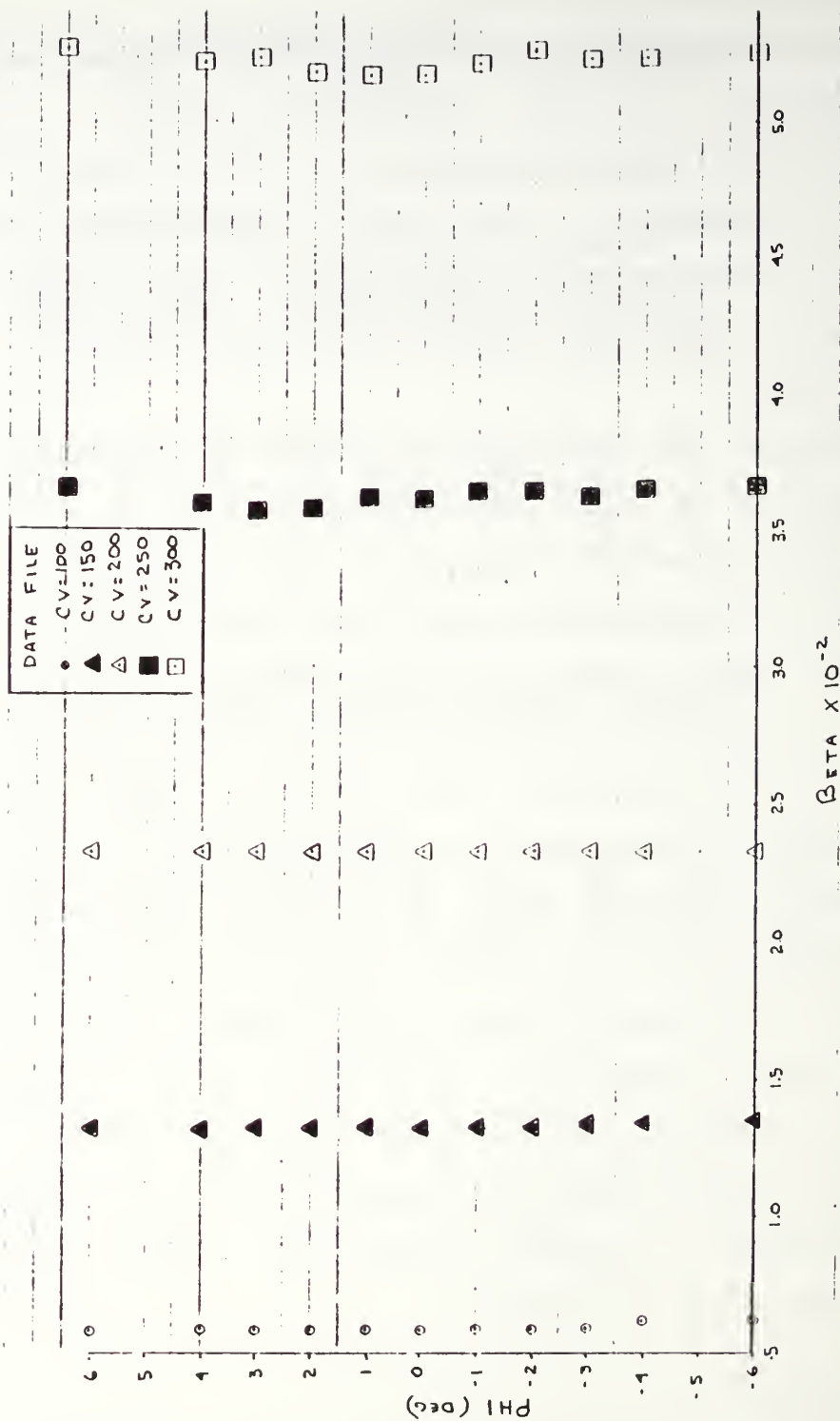


Figure A5. Phi vs. Beta

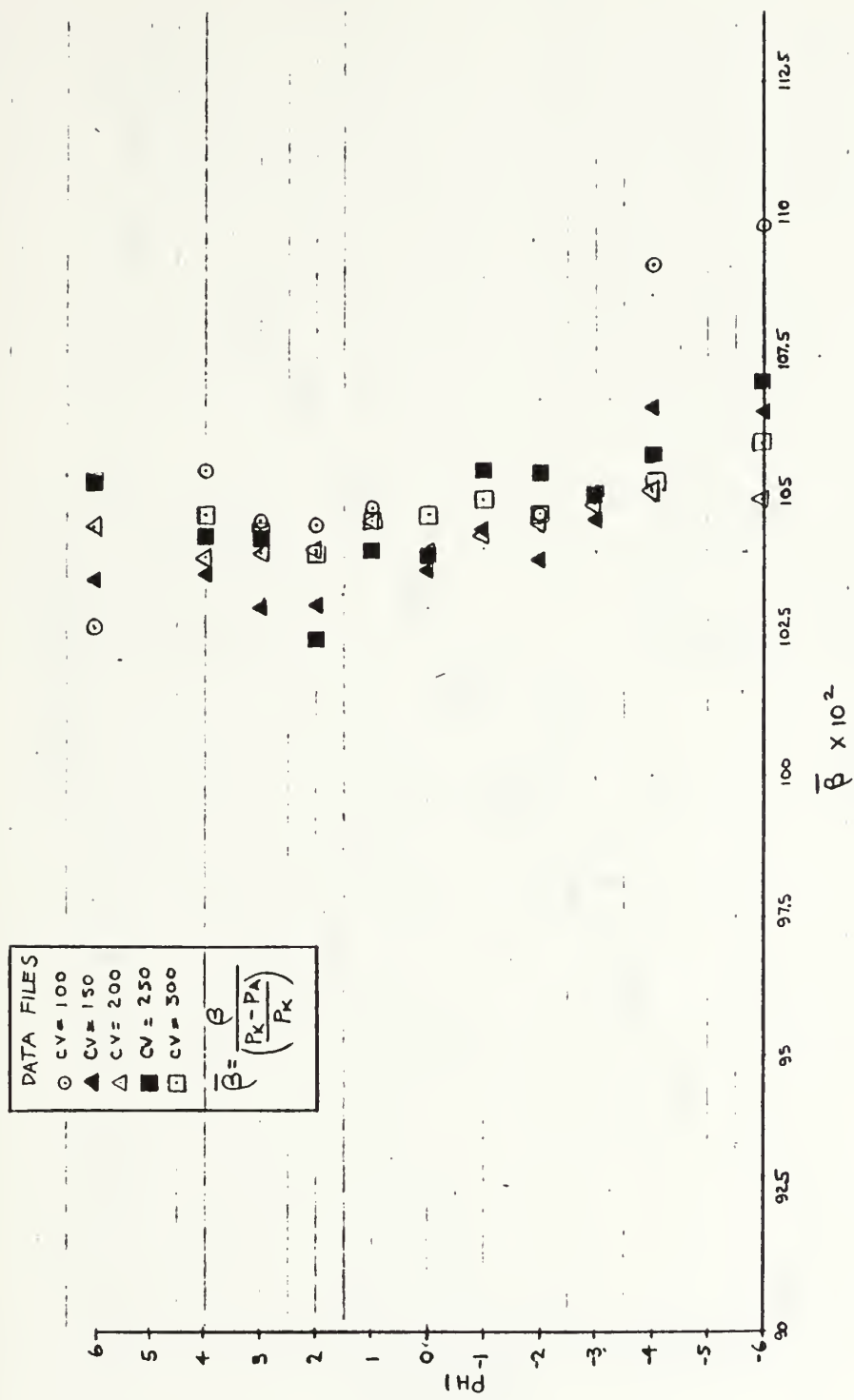


Figure A6. Phi vs. Betabar

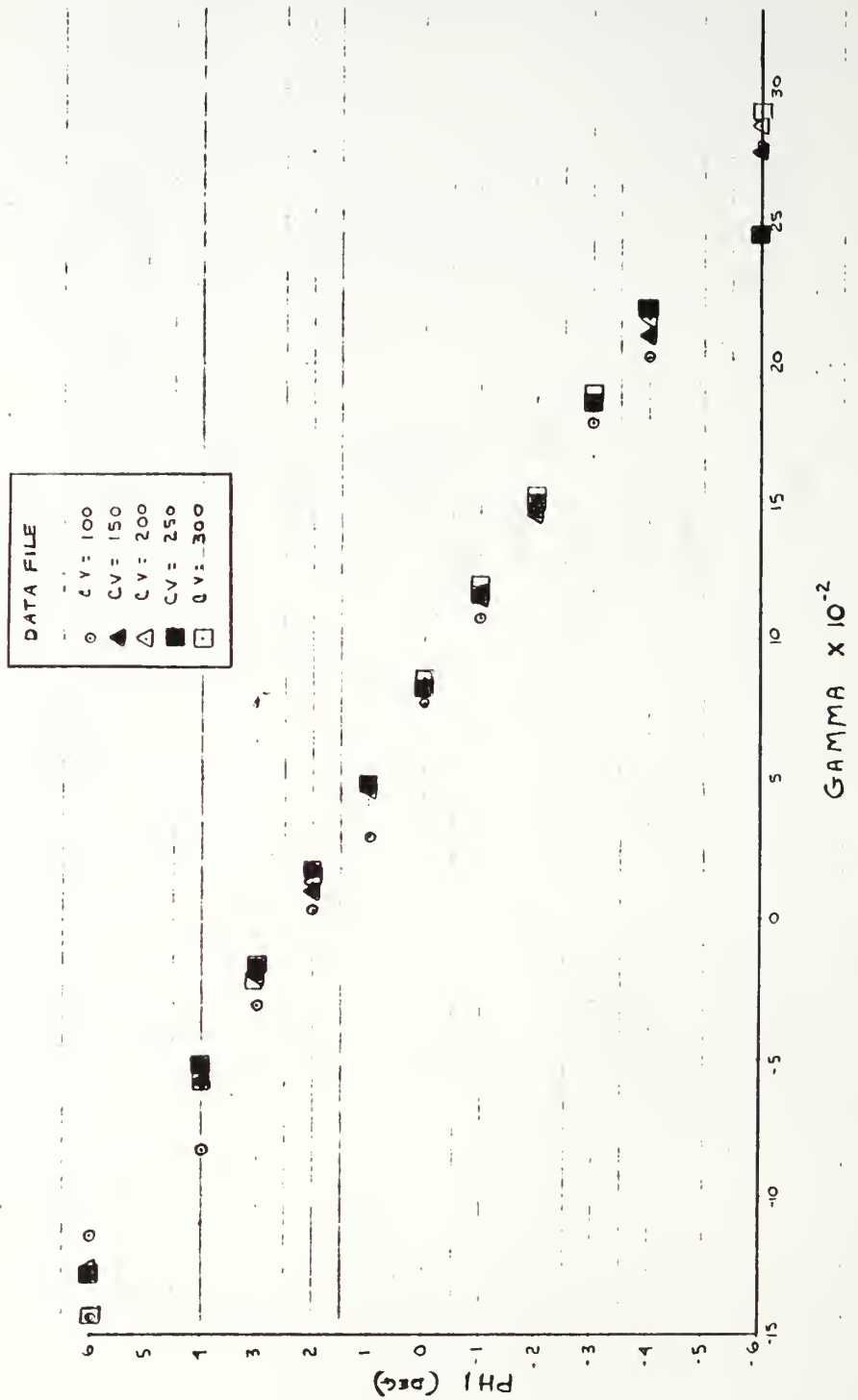


Figure A7. Phi vs. Gamma

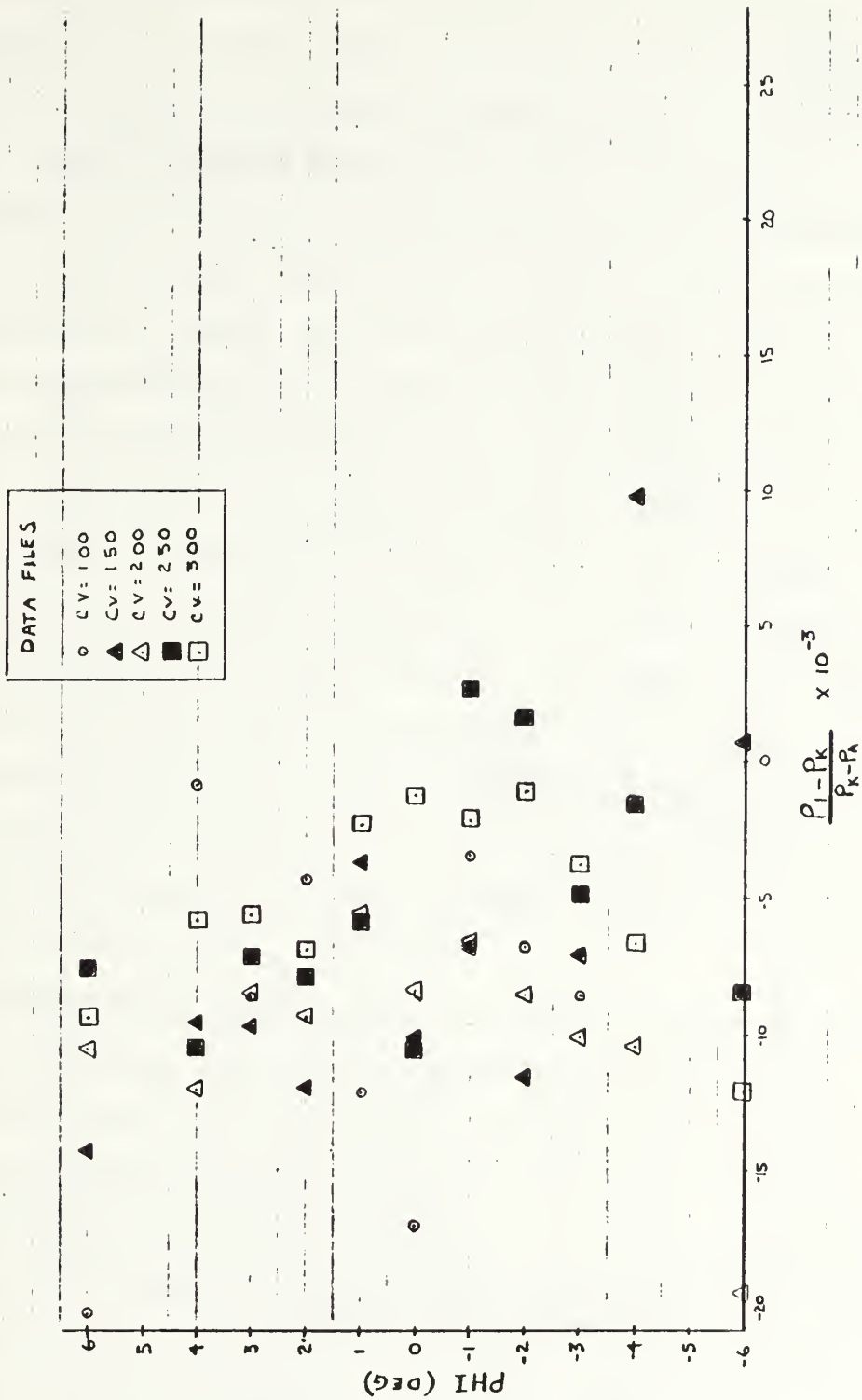


Figure A8. Phi vs. $(P_1 - P_K)/(P_K - P_A)$

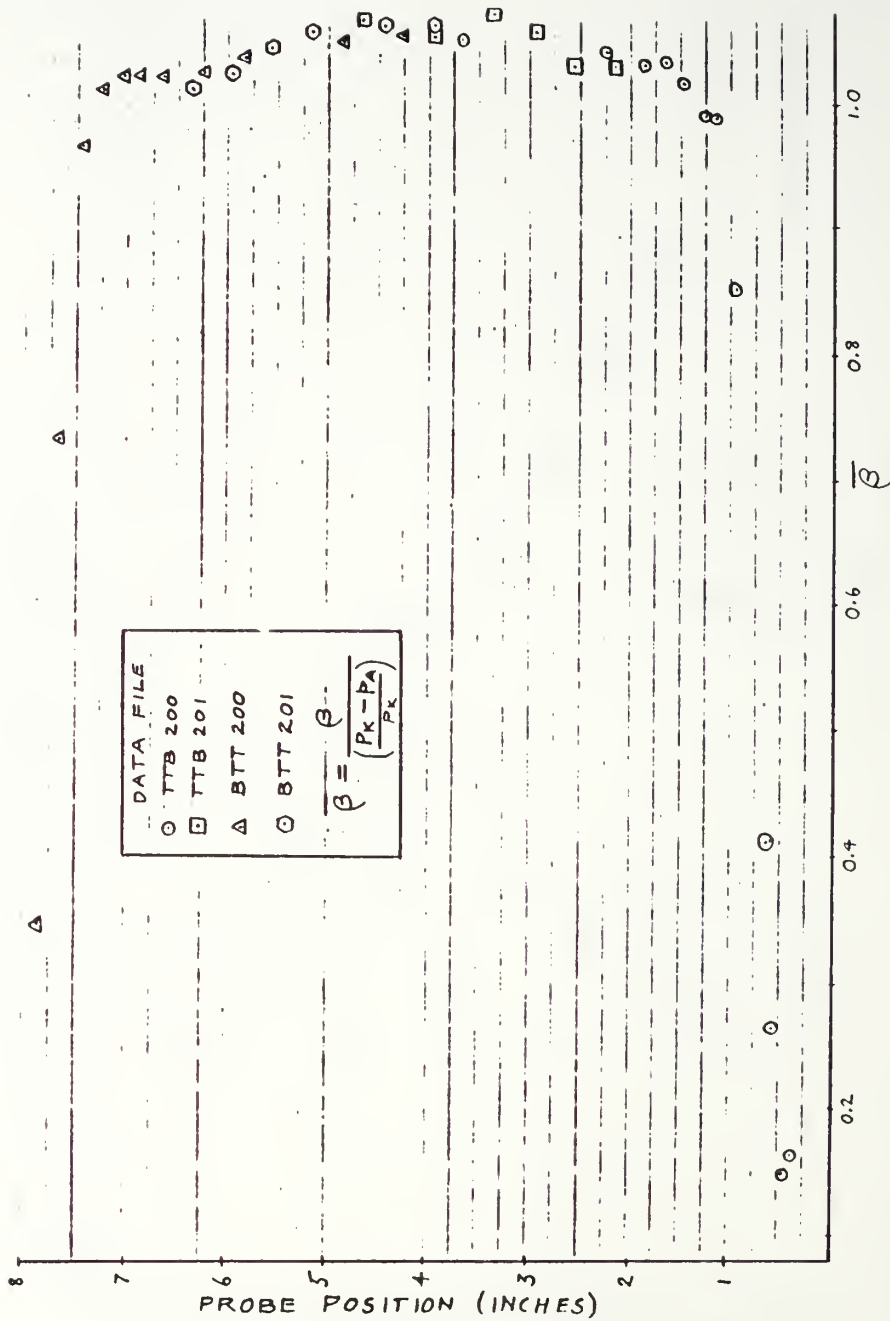


Figure A9. Free Jet Survey: Probe Position vs. Betabar

experience of previous investigators [Ref. 4 and Ref. 12]. Data quality and probe characteristics can be determined from the quantities plotted in these figures. A discussion of the results in each plot follows.

Appendix A of Ref. 12 shows that beta is a function of the non-dimensional velocity X and ϕ with strongest dependence on X ; gamma is a function of X and ϕ but most strongly dependent on ϕ . Fig. A5 shows that as the pitch angle was changed, there was very little change in beta for a given flow velocity. Since beta is related to velocity as developed in Appendix A, Ref. 12, the plot implies that there was a very small change in the measured velocity by the probe with pitch variation, or that beta is slightly sensitive to pitch. The greatest variation in beta is seen in the data from file CV = 300. Beta varied by about 1.3% which equates to about a 1.1% possible variation in velocity. (Change in beta equals change in velocity squared.)

To remove the variations in beta due to changes in the free jet flow, ϕ was plotted against betabar (Fig. A6). By dividing beta by $(PK-PA)/PA$, the effect of the changes in flow through the jet are removed. The plot shows only those changes in beta which are due strictly to pitch angle variation. Ideally, all points for each ϕ should coincide. Some variation is seen at the extreme ϕ values; however, the betabar scale is over expanded by a factor of two compared to a scale appropriate to the

ability to resolve the measurements, and the differences are therefore unnecessarily exaggerated.

Figure A7 clearly shows the strong dependence gamma has on phi. The data points tend to be more closely grouped in the -2 to +2 deg. range with the lower velocity points slightly more separated from the higher velocity points. Part of the reason for this difference may be due to pressure errors at the lower jet velocities having a larger relative effect on the accuracy of the data points.

Total pressure at the conical probe (P1) and total pressure at the Kiel probe (PK) should be nearly identical when phi equals zero. One would expect that the plot in Fig. A8 would reflect this, however it does not. It would be expected that P1 and PK would differ with pitch change, accompanied by some movement of the data points away from zero, but the dispersion of the data in this plot is difficult to explain. The general trend is that nearly all points are less than zero, implying that PK is generally higher than P1. This is corroborated by the free jet survey which shows that the Kiel probe was immersed in a slightly higher velocity region than was the conical probe (see Fig. A9). Note that JOHN4 corrects for this difference when calculating the coefficients. Additionally, it is pointed out by Dreon [Ref. 4] that the core of the free jet has a 0.05 degree pitch to it. The combination of a nonuniform velocity profile and

unsteadiness at low flow velocities might explain some of the observed scatter.

A5. RECOMMENDATIONS

The recommendations presented here focus on software and hardware improvements. The recommendations are:

1. Restore the capability to generate surface plots of the X and phi functional relationship with beta and gamma using the "best fit" polynomial and calibration coefficients. This would provide a visual qualitative check of the fit to the calibration data (Figs. A3 and A4).
2. Modify the HP-9830 based program PRBRED to include the computation of beta bar.
3. Create specific plotting programs on the HP-9830 to plot the quantities in Figs. A5 - A8.
4. Repair or service the printer that supports the HP-21MX system. Frequent malfunctions dramatically slowed the execution of HP-21MX programs.
5. Investigate the feasibility of replacing the HP-9830 with an HP-300 system for probe calibration and related work.

APPENDIX B

SOFTWARE

B1. INTRODUCTION

The software consists of three programs; namely, "ACQUIRE," "CALC," and "LOSS." An in-depth knowledge of computer programming is not required to run the programs; however, some knowledge of programming in Hewlett Packard BASIC 5.0 would be required in order to plot results or make corrections to data files. A rudimentary knowledge of computers by the user is presumed. The main references for the programs are Ref. 13 - 17.

The programs were written to be understandable and flexible. To facilitate understanding program flow, emphasis was placed on clear logic rather than sophistication. To this end, subroutines were called from a library to perform all calculations and repetitive operations. In addition to providing for one or two probe surveys, modifications to hardware addresses on the interface bus or changes to scanner channel assignments can be made easily at the beginning of the program.

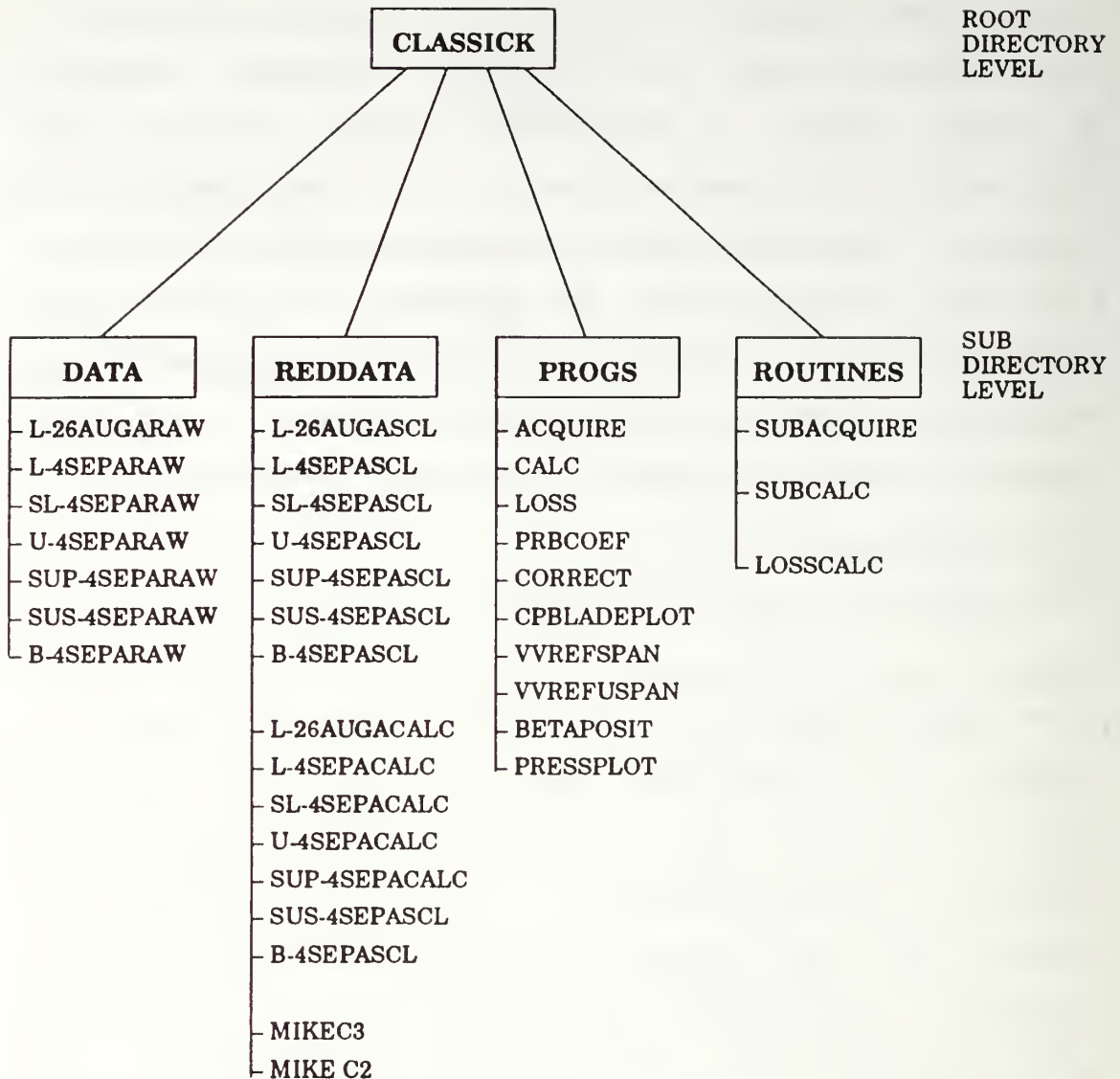
An overview of the file system and program flow is given in sections B2 and B3 respectively, and the step-by-step procedures required to run the programs are given in Section B4, Program Execution. Common errors and recovery steps are addressed in Section B5, and common modifications are discussed in Section B6. Copies of the three main

programs are contained in Section B7 along with examples of the plotting and data file correction programs. Examples of output tables of scaled and reduced data for both detailed blade-to-blade surveys are also contained in this section. Initialization of flexible discs and backing up files to flexible discs is addressed in Section B8. Recommendations to improve the software are presented in Section B9. Finally, for the user, a summary of the steps involved in running the program is given in Section B10.

B2. FILE SYSTEM

Chapter 3 and 10 of Ref. 13 cover mass storage concepts (how the computer's hard disk can be divided up for storage space) and the use of files and directories respectively. The current directory and file system is shown in Fig. B1. Four subdirectories were created under CLASSICK in the root directory. The sub directory DATA contains all the digital voltmeter (DVM) readings during the survey. Scaled data, or raw data that has been scaled in engineering units, e.g., pressure, degrees, etc., are stored in REDDATA, along with the scaled data reduced to useful calculated quantities. The probe calibration coefficients are also stored in REDDATA. The main and ancillary programs are contained under PROGS. ROUTINES contains all the subroutines called by the main programs.

When conducting a probe survey, files need to be created to store the data. Data can be collected from blade-to-blade or span-wise probe surveys or from a scan of



PREFIX

L	Lower Traverse
SL	Span Lower Traverse
U	Upper Traverse
SUP	Span Upper Traverse Pressure
SUS	Span Upper Traverse Suction
B	Blade

SUFFIX

RAW	Raw Voltage Readings
SCL	Scaled
CALC	Calculated (reduced)

Figure B1. File System

the instrumented blade surface pressures. For each survey, raw data, scaled data and reduced data files are created as the user progresses through the programs. The file names are arbitrary but should be descriptive in the interests of identification and kept to a maximum of twelve characters. The file names in this report consisted of a prefix to designate the survey type, followed by the date, run and data type. The prefix and suffix meanings are given in Fig. B1. As an example, the raw data acquired from the lower traverse blade-to-blade probe survey which was conducted on 4 Sept., was named "L-4SEPARAW." If, for some reason, this survey were repeated the same day and the previous survey results were saved, the new file would be named "L-4SEPRAW." The user should define the file names for the proposed surveys before executing the program.

B3. PROGRAM FLOW

The program flow from the user's perspective is shown in Fig. B2(a)-(d). The figures show, verbatim, the prompts the user will see on the screen and the effects that options will have when selected. The selection of options will be addressed in the following section.

B4. PROGRAM EXECUTION

In this section the procedures to power up the system and run the programs will be spelled out. (A summary of the steps for the user to run the programs is given in Section B10.) The intent here is to provide the user with

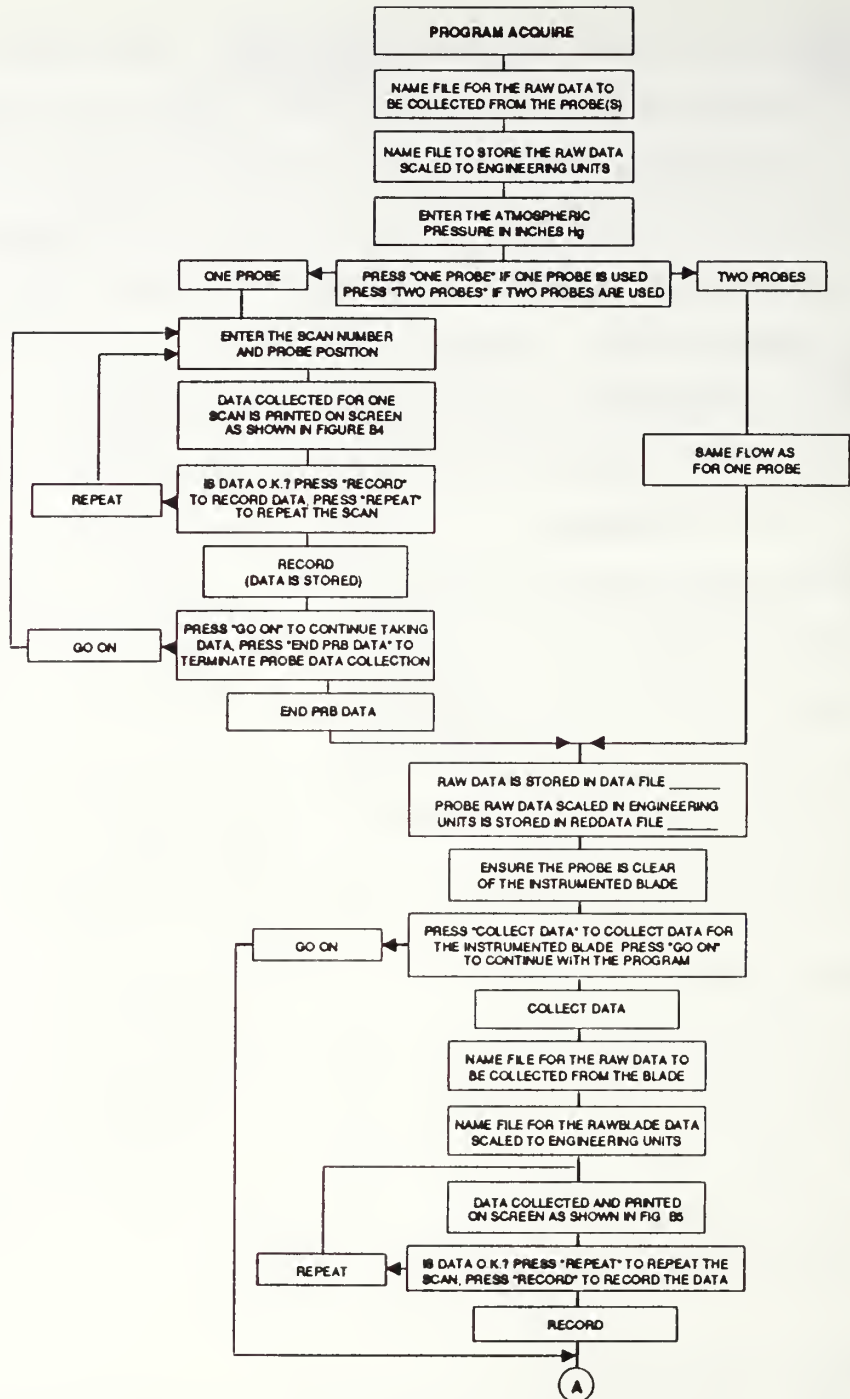


Figure B2(a) Program Flow Chart - ACQUIRE

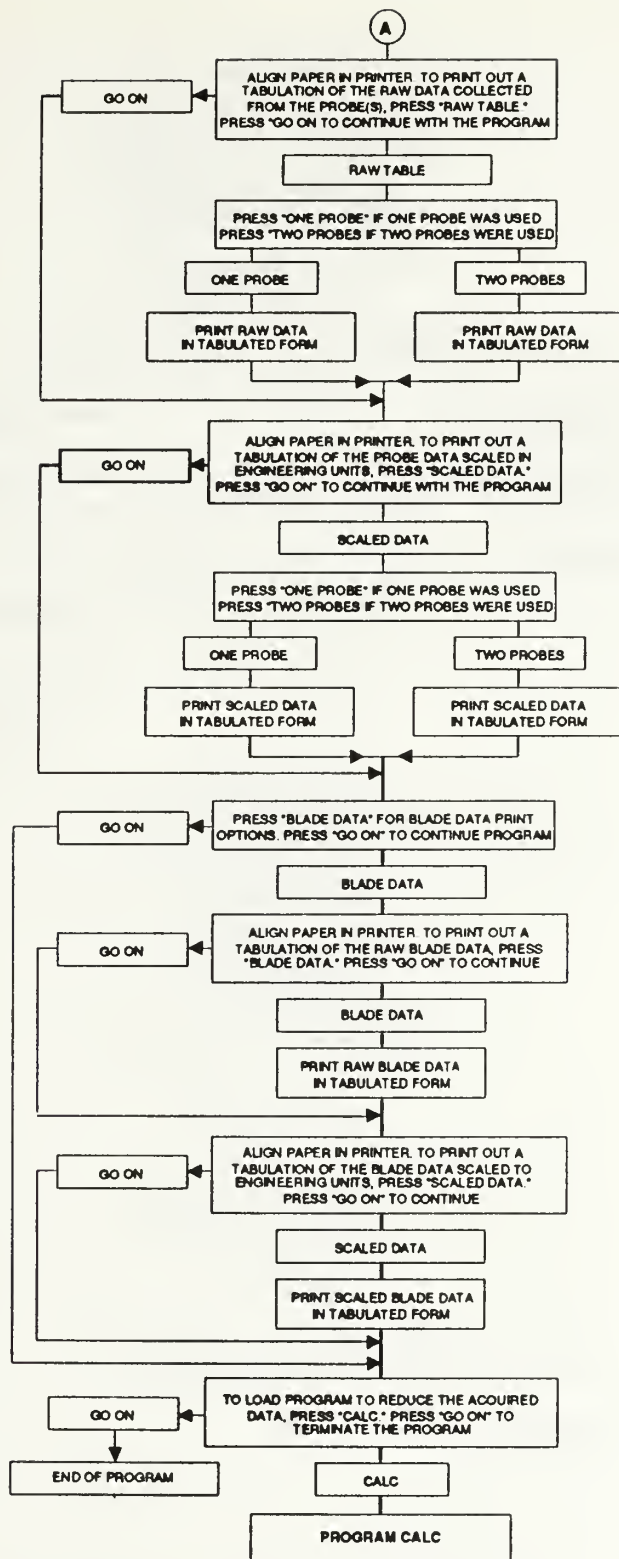


Figure B2(b) Program Flow Chart -
ACQUIRE (cont.)

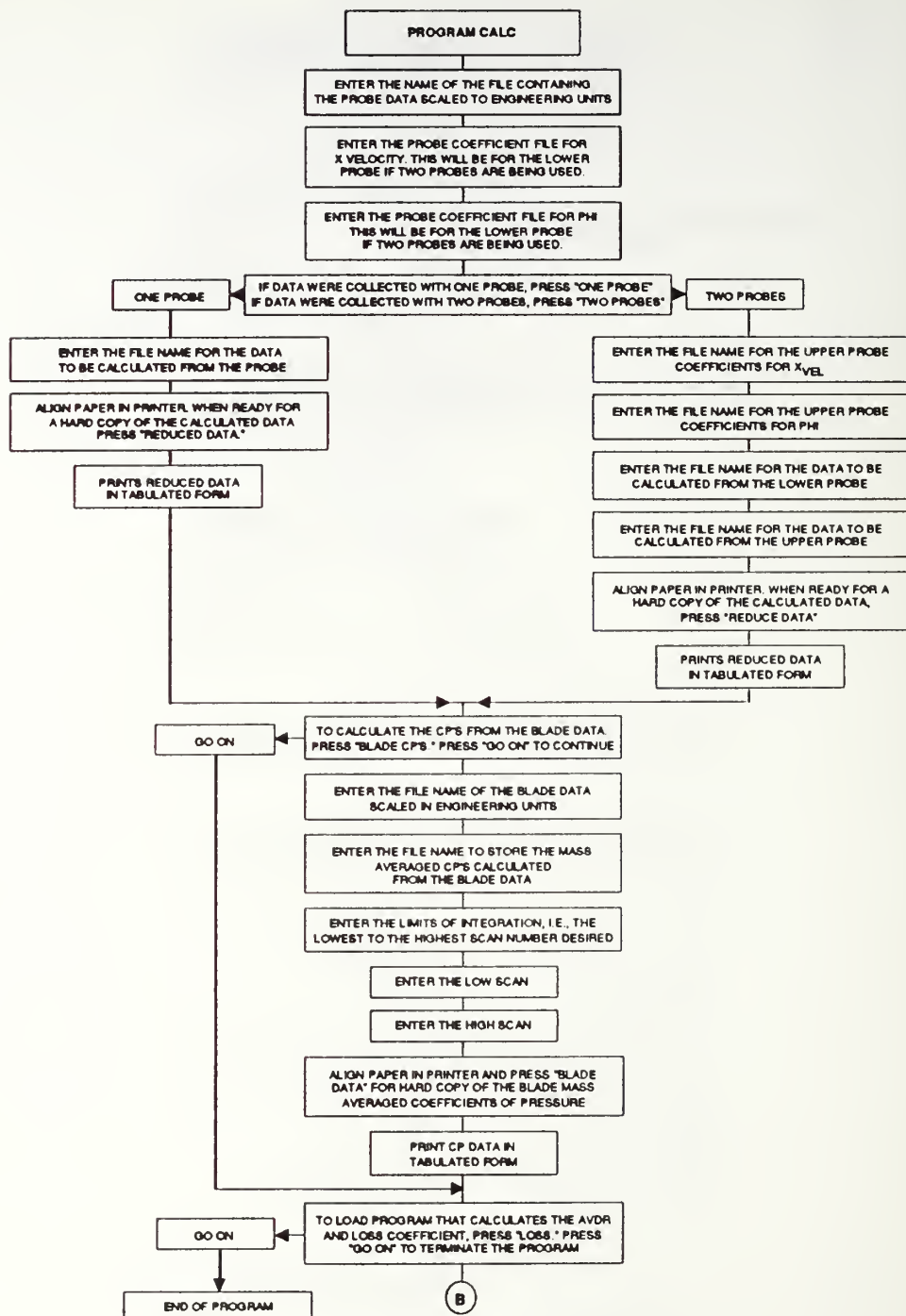


Figure B2(c) Program Flow Chart -
CALC

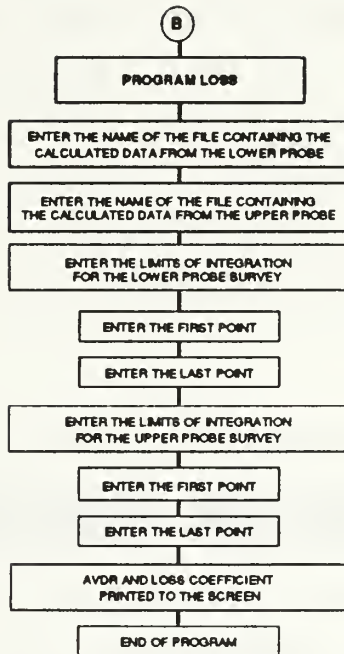


Figure B2(d) Program Flow Chart -
LOSS

the necessary information to acquire and reduce the data in order to obtain the loss coefficient from a set of probe surveys. The program flow chart should be referred to as the program steps are briefly explained.

1. Turn on the DVM, scanner and Scanivalve controller. The computer will not boot-up unless the DVM or scanner is on, however, all of these components must be on before starting the survey.

2. Turn the disk drive on and wait for the self test to complete (two amber lights below the flex disc access extinguish).

3. Turn on the computer, monitor and printer. The printer power switch is located behind the unit.

4. The system will boot up the HP BASIC 5.0 resident on the hard disc and go through a series of self tests. In less than a minute, the Hewlett Packard copywrite statements will appear on the monitor. Soft key labels appear along the bottom of the screen; these correspond to the top row of keys on the keyboard labeled f1 - f8. The key board and an example of what the soft key labels look like for step 12 is shown in Fig. B3.

5. Press f5 corresponding to the soft key label LOAD.

6. Type /CLASSICK/PROGS/ACQUIRE between the quotation marks. Press RETURN. This establishes the path from

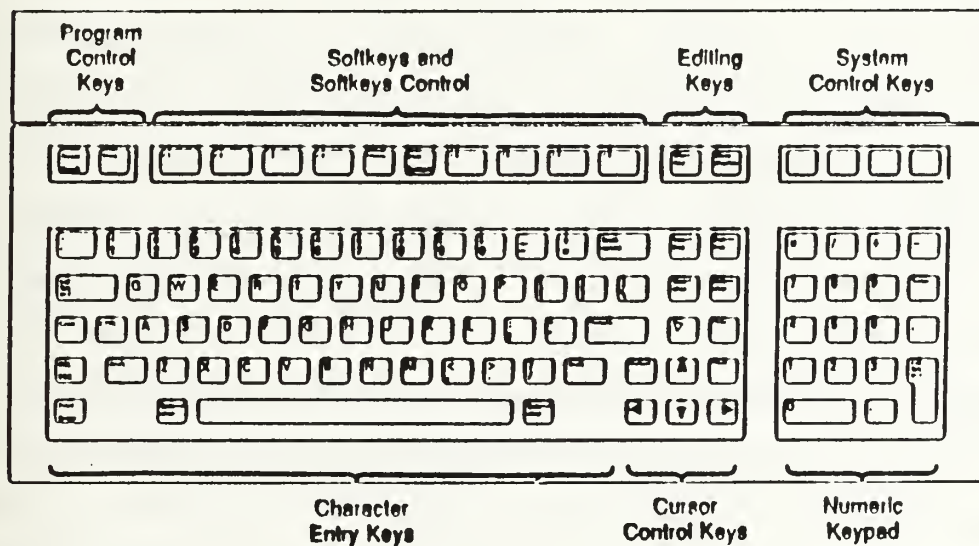
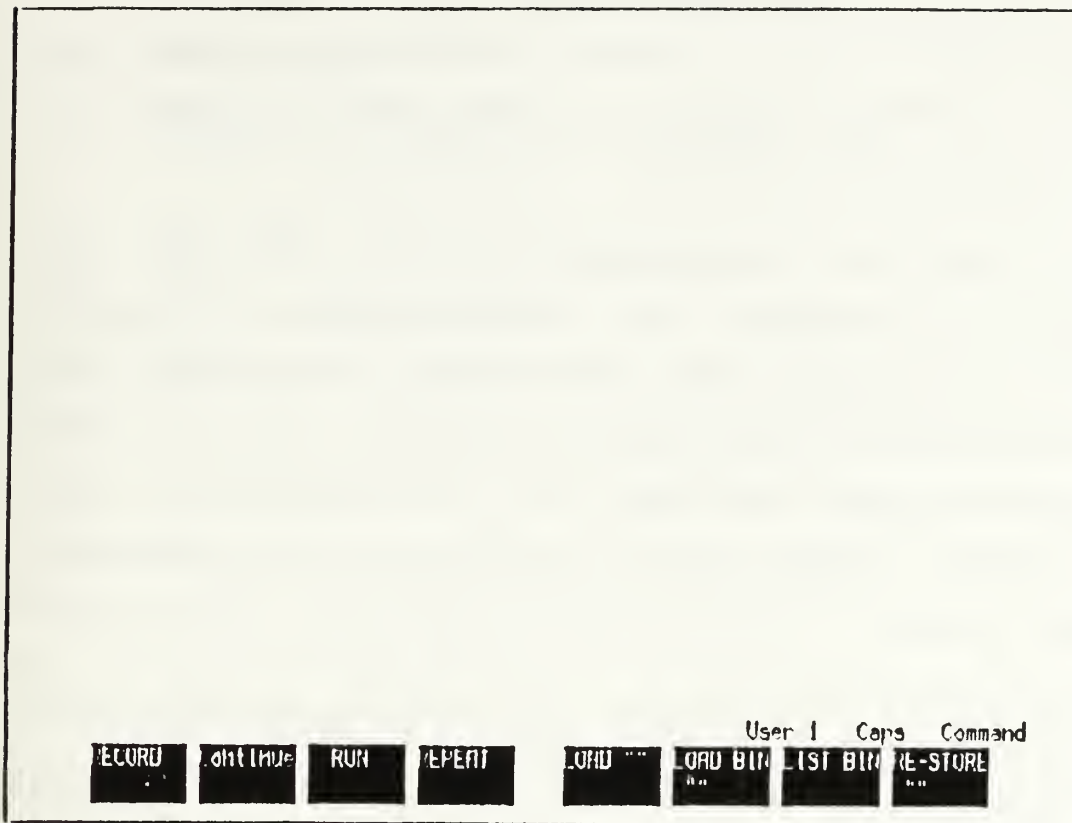


Figure B3. Keyboard and Softkey Labels

the root directory where the CLASSICK directory is located to the file ACQUIRE via the subdirectory PROGS. An alternate way of doing this would be to type in at the blinking cursor the word LOAD followed by "/CLASSICK/PROGS/ACQUIRE." Press RETURN.

7. Press f3 corresponding to the soft key label RUN. The first prompt in the ACQUIRE program will appear. From the program flow chart, it can be determined that the prompt will read "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE PROBE(S)." The file name is typed in directly without quotation marks, e.g., L-2SEPARAW. Press ENTER.

8. At the next prompt, type in the scaled data file, e.g., L-4SEPASCL. Press RETURN.

9. Type in the atmospheric pressure in inches of mercury, e.g., 29.92. Press RETURN. In the program this defines the variable Pbaro as equal to 29.92. This will normally be constant throughout the duration of a survey, however, in the rare event of a weather front passing through, the barometric pressure can change during the survey. If the change is significant, the variable Pbaro can be redefined while the program is running by performing the following steps:

- a. Press the STOP key next to key f1.
- b. Type Pbaro 30.00 to change from 29.92 to 30.00.
- c. Press RETURN.
- c. Press f2 corresponding to soft key label CONTINUE.

10. Once step 9 has been completed, the one or two probe option prompt appears, and the soft key labels EDIT and SCRATCH corresponding to keys f1 and f4 respectively are replaced by ONE PROBE and TWO PROBES. Press the appropriate key. Note that the only soft keys the user will press during normal program execution will be those corresponding to keys f1 and f4. It will be assumed in the following steps that the one probe option was used - the only difference in procedure will be an additional position that the user must enter for the second probe.

11. The scan number and position are typed in and separated by a comma, e.g., 43, 2.55. Press RETURN. The scan number can be up to four characters and the position, seven characters - four to the left and two to the right of a decimal.

12. The scan begins after RETURN is pressed for step 11. All the data for the scan will print to the screen for the user to evaluate. An example of the screen presentation is given in Fig. B4. If the data is unsatisfactory, press f4 corresponding to soft key

```

*****
SCAN NUMBER 2
PROBE POSITION 200
PORT      VOLTAGE      GUAGE PRESSURE( INCHES H2o )
1          4.000E-07      4.000E-03
2          9.052E-04      9.048E+00
3          1.182E-03      1.182E+01
4          -6.170E-04      -6.174E+00
5          5.254E-04      5.250E+00
6          -6.560E-05      -6.600E-01
7          -6.380E-05      -6.420E-01
8          -3.060E-05      -3.100E-01
9          -1.106E-04      -1.110E+00
10         1.016E-03      1.016E+01
11         -6.790E-04      -6.794E+00
12         4.000E-07      0.000E+00
13         -2.600E-06      -3.000E-02
14         6.000E-07      2.000E-03
*****
YAW CHAN READING      .0023624
YAW (DEGREES)         2.3624
TEMP CHAN READING     -.0012328
TEMPERATURE (DEGREES R) 452.445752
ATMOSPHERIC PRESS (INCHES) 30.00 (Hg)      407.10(H2o)
*****

IS DATA OK? PRESS "RECORD" TO RECORD DATA, PRESS "REPEAT" TO
REPEAT THE SCAN.

*****

```

Figure B4. Data Printed on the Screen -
One Probe Scan

label REPEAT. This will return the program to step 11. If the data is satisfactory, press f1 corresponding to soft key label RECORD. The disc drive amber light will flash momentarily as the data is stored on the disk.

13. Press GO ON to continue taking more data. This will return the program to step 11 again and the cycle repeats until the survey is terminated by pressing END PRB DATA.

14. A statement appears informing the user what file names the raw and scaled data files are under. This is just a reminder and requires no action.

15. The next statement is a reminder to clear the probe away from the instrumented blade before collecting a blade surface pressure distribution.

16. Options appear to either collect the blade data or by-pass this operation and go on to the print options.

17. The collect option requires file names for the raw and scaled data. Type the names as was done in steps 7 and 8.

18. The scan begins after RETURN is pressed for step 17. The blade data will be printed on the screen. As in step 12, the scan can be repeated if the data is unsatisfactory. An example of the screen presentation

is given in Fig. B5. Similarly, the data is stored when RECORD is pressed.

19. After recording blade data, there follows a series of print options for the stored probe and blade data. The steps are readily apparent from the program flow chart. Note that this is the only time to obtain a hard copy of the raw and scaled probe and blade data. Currently a program does not exist to print the data from an arbitrary file in the tabulated format produced by the ACQUIRE program.

20. The last step in program "ACQUIRE" is the option of terminating the program by pressing GO ON or loading the reduction program "CALC" by pressing CALC. If the data collected is to be reduced at a later time, then GO ON is the correct choice. Later, when the user is ready to reduce the data, program "CALC" is executed by following steps 5 and 6 except type /CLASSICK/PROGS/CALC; press RETURN, then press soft key RUN.

21. Once "CALC" is executed, the first prompt that appears is "ENTER THE NAME OF THE FILE CONTAINING THE PROBE DATA SCALED TO ENGINEERING UNITS." This is the scaled data file produced during the execution of "ACQUIRE." A new file is not being created at this time - the entry allows "CALC" to reduce the data in

SCAN NUMBER PORT	VOLTAGE	BUAGE PRESS(INCHES H2O)
1	1.000E-06	1.000E-02
2	9.008E-04	8.998E+00
3	1.206E-03	1.205E+01
4	-3.380E-04	-3.390E+00
5	-1.048E-04	-1.058E+00
6	2.380E-05	2.280E-01
7	8.000E-05	7.900E-01
8	9.780E-05	9.680E-01
9	8.300E-05	8.200E-01
10	6.240E-05	6.140E-01
11	8.260E-05	8.160E-01
12	7.260E-05	7.160E-01
13	8.500E-05	8.400E-01
14	1.712E-04	1.702E+00
15	2.334E-04	2.324E+00
16	2.144E-04	2.134E+00
17	1.334E-04	1.324E+00
18	1.728E-04	1.718E+00
19	2.270E-04	2.260E+00
20	3.804E-04	3.794E+00
21	4.674E-04	4.664E+00
22	6.896E-04	6.886E+00
23	-1.709E-03	-1.710E+01
24	-3.333E-03	-3.334E+01
25	-3.202E-03	-3.203E+01
26	-2.779E-03	-2.780E+01
SAMPLE EXCEEDED MAXIMUM DEVIATION ALLOWED-SAMPLE RETAKEN		
27	-2.068E-03	-2.069E+01
28	-1.631E-03	-1.632E+01
29	-1.411E-03	-1.412E+01
30	-1.238E-03	-1.239E+01
31	-1.043E-03	-1.044E+01
32	-8.212E-04	-8.222E+00
33	-6.908E-04	-6.918E+00
34	-5.584E-04	-5.594E+00
35	-4.712E-04	-4.722E+00
36	-4.158E-04	-4.168E+00
37	-3.784E-04	-3.794E+00
38	-3.608E-04	-3.618E+00
39	-3.350E-04	-3.360E+00
40	-3.232E-04	-3.242E+00
41	-3.068E-04	-3.078E+00
42	-2.922E-04	-2.932E+00
43	3.334E-04	3.324E+00
44	-9.170E-04	-9.180E+00
45	-3.214E-04	-3.224E+00
46	1.446E-04	1.436E+00
47	9.420E-05	9.320E-01
48	-2.656E-04	-2.666E+00

.....

IS DATA OK? PRESS "REPEAT" TO REPEAT THE SCAN, PRESS "RECORD"
TO RECORD THE DATA.

.....

Figure B5. Data Printed on the Screen -
Instrumented Blade Scan

the scaled data file to useful engineering quantities. Type the file name, e.g., L-4SEPASCL. Press RETURN.

22. The next two prompts are to allow "CALC" access to the probe calibration coefficient file - one for X and one for Phi. For this study the X file was MIKEC3 and the Phi file was MIKEC2. Type these file names in at the prompt followed by RETURN.

23. The one or two probe option appears next. The difference between the two choices, is in the prompts displayed. Two probes require two additional calibration coefficient files to be accessed - hence the prompts for the upper probe coefficient file for X and Phi.

24. The prompt "ENTER THE FILE NAME FOR THE DATA TO BE CALCULATED FROM THE PROBE," requires the user to create a new file for the data about to be reduced from the scaled data file. Type the file name, e.g., L-4SEPAACALC. Press RETURN. Note that for the two-probe survey, an additional file must be created for the second probe, even though only one scaled data file was created in "ACQUIRE" for either a one or two-probe survey.

25. The next prompt will remain on the screen until the REDUCED DATA soft key is pressed. It is assumed that the "CALC" program would not be executed unless a

hard copy of the reduced data were desired, hence, no other options are available.

26. The option to calculate the mass averaged coefficient of pressure from the instrumented blade data appears next. Pressing GO ON bypasses this calculation. Pressing BLADE CP'S prompts the user for additional information.

27. As in step 21, type in the scaled blade data file, e.g., B-4SEPASCL. Press RETURN.

28. As in step 24, type in the name of the file to be created for the blade C_p 's, e.g., B-4SEPACALC. Press RETURN.

29. The next prompt requires the user to supply the limits of integration for the probe survey file entered in at the beginning of "CALC" e.g., L-4SEPASCL. This file contains data for the blade-to-blade survey upstream at midspan, which is the inlet condition to the instrumented blade. (The taps are located at midspan.) Quantities obtained from the blade-to-blade scaled file and reduced file are mass averaged for the C_p calculation as shown in Table I. The limits of integration are determined by noting what the beginning and ending scan numbers are. In the case of L-4SEPASCL, the first scan was 1 and the last scan, 31. For "ENTER THE LOW SCAN", type 1. Press RETURN. For

"ENTER THE HIGH SCAN", type 31. Press RETURN. Note that it is not the position that is entered, but the scan number corresponding to the position that is entered. Additionally, the integration limits can be over a shorter interval than the entire length of the survey if desired.

30. The prompt to print the blade C_p 's appears once the computer completes the C_p calculations.

31. The final prompt in "CALC" allows the user to terminate the program by pressing GO ON or to execute program "LOSS" by pressing LOSS. To calculate the AVDR and loss coefficient, requires an upper and a lower blade-to-blade survey. The execution of "LOSS" at this point would not be appropriate unless the user has a reduced file for an upper and lower blade-to-blade probe survey.

32. If program "LOSS" was not executed by pressing the LOSS soft key in step 31, then it can be executed by pressing the LOAD soft key and typing /CLASSICK/PROGS/LOSS between the quotation marks and pressing RETURN. Press the RUN soft key.

The static pressure rise coefficient, AVDR and loss coefficient are calculated from quantities contained in the reduced files of the upper and lower blade-to-blade surveys as shown in Table I. The

entries for the prompts provide the program access to the reduced data files.

33. The prompt "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE LOWER PROBE" requires the user to enter the file name for the lower probe blade-to-blade survey data that was reduced in "CALC" e.g., L-4SEPACALC. Press RETURN.

34. The next prompt pertains to the upper probe blade-to-blade survey reduced data e.g., U-4SEPACALC. Press RETURN.

35. Integration limits for the lower probe blade-to-blade survey are requested next. As noted in step 29, it is the scan number corresponding to the lower limit of the integration interval that is entered for "ENTER THE FIRST POINT." Likewise, the scan number for the upper limit of the integration interval is entered for "ENTER THE LAST POINT."

36. Limits of integration, in terms of scan number, are requested again for the upper probe blade-to-blade survey.

Note that the upper and lower integrations must be the same, exact, integral number of blade spaces (usually one), but the number of scans to cover the same distance will probably be different. It is vitally important to ensure that correct scan numbers,

match desired integration limits when the integration interval is something other than the beginning and ending of a blade-to-blade survey.

37. The calculations are performed and the static pressure rise coefficient, AVDR and loss coefficient are printed on the screen; the program then terminates.

B5. COMMON ERRORS AND RECOVERY STEPS

B5.1 Introduction

Common errors germane to the program execution are outlined in this section. Errors for each program are covered rather than broad categories of errors. Specific recovery steps are given which, in some cases, require knowledge of the program structure. Since probe surveys are time consuming, it behooves the investigator to be familiar with the program. A mistake in many cases may be rectified by stopping the program, then continuing at a specific line in the program. To this end, a copy of the three main programs should be available during a survey. A listing of the programs may be obtained by following the steps outlined in Section B6. In those cases where a specific recovery step cannot be made, the user is referred to Ref. 13-17. A complete listing and description of system errors can be found in Ref. 16.

While not specifically an error associated with program execution, the new user may become lost in the directory. The Mass Storage Is or MSI command (addressed in Ref. 13),

in conjunction with a path name, allows the user to move through the directory levels. The command `MSI"/` places the system in the root directory while the command `MSI"/CLASSICK`, places the system in the CLASSICK directory which is subordinate to the root directory. Executing any of the three main programs by following the steps in Section B4 will initially place the system in the PROGS subdirectory. As the program runs, the subdirectory will change to facilitate entry of the various file names. In all cases when the programs have terminated, the system is in the REDDATA subdirectory. The program can be repeated even from this subdirectory by pressing RUN. However, if the user decides to move somewhere else in the directory, the MSI command and path name must be used. As an example, upon "CALC" termination it is desired to execute "ACQUIRE." The command `MSI "/CLASSICK/PROGS` puts the system in the PROGS subdirectory. "ACQUIRE" can then be loaded from the subdirectory PROGS by pressing LOAD and typing ACQUIRE between the quotation marks.

Alternatively, "ACQUIRE" could have been loaded from subdirectory REDDATA by pressing LOAD followed by typing `"/CLASSICK/PROGS/ACQUIRE`".

B5.2 ACQUIRE

1. Errors Involving File Names

These errors will most likely be the result of either attempting to enter a file name which exceeds twelve characters or entering an undesired file name. If a

system error is returned while attempting to enter a file name and it is suspected that the name exceeded twelve characters, reenter the file name using twelve characters or less. Refer to Ref. 16 for other system errors.

Undesired file names which have been entered into the system i.e., the file was created, can be handled in different ways. Assuming no data had been collected, the program could be aborted, the undesired file name purged and the program reexecuted. The steps for this would be:

- a. Press STOP (This is a labeled key on the top row).
- b. Type MSI "/CLASSICK/SUBDIRECTORY NAME" (subdirectory name is either DATA for rawdata files or REDDATA for scaled or reduced data files).
- c. RETURN
- d. Type PURGE "UNDESIRE FILE NAME" (include quotation marks).
- e. RETURN
- f. Press LOAD
- g. Type /CLASSICK/PROGS/ACQUIRE between quotation marks.
- h. RETURN
- i. Press RUN

Alternatively, the program could be run with the undesired file name and the name changed after terminating "ACQUIRE." The steps for this would involve writing a short program.

2. Incorrect Atmospheric Pressure Entry

The required steps are as follows:

- a. Press STOP
- b. Type Pbaro = CORRECT VALUE
- c. RETURN
- d. Press CONTINUE

3. Incorrect Probe Option Selected

The required steps are as follows:

- a. Press STOP
- b. Type CONT 145

[Line 145 is the line number which the program would have to return to in order to generate the probe option prompt again.]

- c. RETURN

4. Incorrect Scan Number or Probe Position Entered

Upon pressing RECORD, an error statement will be returned if the scan number was entered out of sequence. This will prevent the data from being stored. Take the following steps:

- a. Press STOP
- b. Type CONT 162 for a one probe survey
- c. Type CONT 160 for a two probe survey

[These are the line numbers in the program that return the prompt for entering the scan number and position.]

- d. RETURN

An incorrect position entry will not return an error statement. A correction to position can be done using a version of program "correct" after completion of the survey.

5. Premature Termination of Data Collection

If END PRB DATA was mistakenly pressed, the ability to continue with probe data collection can be regained by these steps:

- a. Press STOP
- b. Type CONT 162 for a one probe survey
- c. Type CONT 160 for a two probe survey
- d. RETURN

6. By-passed Collecting Blade Data Mistakenly

The required steps are as follows:

- a. Press STOP
- b. Type CONT 357. [This line number returns the blade data collection option prompt.]
- c. RETURN

7. By-passed Hard Copy Print Options Mistakenly

The required steps are as follows:

- a. Press STOP
- b. Type CONT 408. [Line 408 is the beginning of the hard copy option prompts.]
- c. RETURN

B5.3 CALC

1. Incorrect File Entered

The "CALC" program will reduce any scaled data file obtained from "ACQUIRE." If an undesired file name was entered, abort the program then reexecute it using the following steps:

- a. Press STOP
- b. Press RUN

2. Incorrect Probe Coefficient File Entered

The required steps are as follows:

- a. Press STOP
- b. Type CONT 144. [Line 144 will return the prompt for entering the X velocity coefficient file.]
- c. RETURN

3. Incorrect Probe Option Selected

The required steps are as follows:

- a. Press STOP
- b. Type CONT 200 [Line 200 returns the probe option prompt.]
- c. RETURN

4. Incorrect Reduced Data File Name Entered

"CALC" is short enough to allow termination and reexecution of the program in order to enter the correct desired file name for the reduced data. The steps to do this are:

- a. Press STOP
- b. Press RUN

The undesired file name can be purged from the REDDATA subdirectory by following the steps in paragraph "1" of Section B5.2. If "CALC" is to be executed after the purge operation, press LOAD and type /CLASSICK/PROGS/CALC between the quotation marks. Press RETURN followed by pressing RUN.

5. By-passed Blade C_p Calculations Mistakenly

The required steps are as follows:

- a. Press STOP
- b. Type CONT 736. [Line 736 returns the blade C_p calculation option.]
- c. RETURN

6. Incorrect Limits of Integration Entered

Unless the limits entered are non existent, no error will be returned--only erroneous data if the limits are wrong. If the C_p values do not look correct, the calculation can be repeated if the integration limits are suspected to be in error. Perform the following:

- a. Press STOP
- b. Type CONT 736. [This will return the blade C_p calculation option. A new reduced blade data file name will have to be entered since the previous file name contains the suspect C_p reduced data. This suspect file can be purged following the steps in paragraph 1, Section B5.2.]
- c. RETURN

B5.4 LOSS

"LOSS" is a short program; any errors in entering the prompted entries can be handled by terminating the program and starting again. The steps are:

- a. Press STOP
- b. Press RUN

B6. MODIFICATIONS

B6.1 Introduction

The programs were written to accomodate changes that might be expected to occur in the equipment set-up of the cascade facility. Variables defining scanner channel assignments, HP-IB equipment addresses and other variables that might change as the investigations are modified were placed at the beginning of the program. Thus, all such changes are made in one section of the code. Those variables embedded in the program such as temperature, yaw and position are cited by line number to allow modifications to be made in the way they are evaluated. Array elements were redefined when necessary. Changes to array elements require familiarization with the program structure. All changes should be followed up with a revalidation of the modified code prior to acquiring new survey data.

Program modifications are made and their effects evaluated best by examining a hard copy of the program.

Obtain a copy of any program in the PROGS subdirectory by performing the following steps:

- a. Type MSI"/CLASSICK/PROGS"
- b. RETURN
- c. Type CAT [This will list all the programs or files in the PROGS subdirectory. After identifying the desired program, proceed with the next step.]
- d. Type PRINTER IS 701 [Output is now directed to the printer.]
- e. RETURN
- f. LOAD "DESIRED PROGRAM"
- g. RETURN
- h. Type LIST
- i. RETURN [The program will now be printed.]

Note that after the program is printed, return the system to print on the screen by typing PRINTER IS 1, followed by RETURN.

Once the changes have been identified, refer to Chapter 11, of Ref. 13 to edit and store the modified program.

B6.2 Common Changes

In "ACQUIRE" the common variables that might be changed are listed in the front of the program along with a plain language description of what the variable represents. It is assumed the user will understand the rudiments of the acquisition system prior to making any variable changes.

B6.3 Temperature, Yaw and Position Changes

The variable Temp on line 245 of "ACQUIRE" is defined by an equation that represents the characteristics of the iron-constantan thermocouple used in the present work. This equation will change if the thermocouple changes. Edit this line with appropriate changes to account for a thermocouple change.

Referencing the yaw angle to a precisely known horizontal or vertical axis as outlined in Appendix C requires a correction to the yaw transducer output. This correction can be made in "ACQUIRE" by modifying line 240 for a one probe survey or lines 207 and 212 for a two probe survey. An alternative to this would be to modify "CALC". Change line 626 for a one probe survey; change lines 359 and 491 for a two probe survey.

Incorporating the use of linear potentiometers for probe position read-out is a more extensive modification to "ACQUIRE" which will be briefly summarized for a one probe survey. A scanner channel for the potentiometer transducer must be assigned and this channel defined by a variable name. The variable must be included in the COM statement on line 169 and in line 754 of the subprogram "Readdvm". A CALL statement similar to that listed for the Yaw and Temp channel readings on lines 238 and 242, is required. A statement allowing the transducer channel to be read by the DVM must be included in the IF-ELSE structure of "Readdvm". Array elements presently defining

probe position must be modified if necessary and traced through "CALC".

B6.4 Array Elements Changes

In "ACQUIRE," Scanivalve port readings, in addition to other quantities are assigned an array element. A change in an array element assignment may require a change in the formatted print statements and headings. Additionally, since array elements are redefined during the execution of the three main programs, a trace through those programs is necessary to ensure that any changes in array element assignments are consistent.

B.7 PROGRAMS AND DATA

A complete listing of the program and data files is given in the Table of Contents for Appendix B. The three main programs have been previously explained. The listed subprograms are called by the main programs from the ROUTINES subdirectory during execution. The plot programs are specifically those used to plot some of the data in the present study. The following is a list of the figures corresponding to the plot program written for it:

<u>Program</u>	<u>Figure</u>
PREFPQREF	18
BETAPOSIT	19
VVREFSPAN	8
VVREFUSPAN	11
CPBLADEPLOT	23

Plots are printed to the printer by pressing DUMP GRAPHICS. Samples of the programs to correct erroneous data points or to rereference the probe-displacement are included. "CORRECT A" (Section B7.12) was used to extrapolate the recorded data to add an additional scan. This was done to enable data to be integrated over exactly one blade space. The artificially generated scan does not appear in Table B4 but does appear in Table B5. "CORRECT B" (Section B7.13) provided the means to correct an incorrect value of probe position entered during a scan. The corrected value then appears in Table B5. "CORRECT C" (Section B7.14) was used to rereference displacement values of file SUS-4SEPASCL (example not included) to make the midspan position equal to zero.

The probe calibration coefficients were stored in a file using "PRBCOEF" (Section B7.15) with actual coefficients in the DATA statement in lieu of those in the example. Note that the DATA statement must contain 36 entries to be consistent with the way the file is used in the program "CALC."

The remainder of the tables have been previously addressed.

B7.1 Acquisition Program ACQUIRE

```

10      IPROGRAM ACQUIRE
11      ITHIS PROGRAM ACQUIRES DATA FROM 5-HOLE PROBE SURVEYS AND PRESSURE
12      IOISTRIBUTION FROM AN INSTRUMENTED BLADE. SEE CLASSICK M.S. THESIS
13      ISEPT 89 FOR PROGRAM DESCRIPTION AND DETAILS.
14
15      I..... DIMENSION ARRAYS .....
16
17      OPTION BASE 1          IBASE OF ARRAY WILL BE ONE INSTEAD OF ZERO
18      DIM Rawdat(1,106)     ITHIS ARRAY WILL ACCOMMODATE BOTH 48 PORT
19                               ISCANIVALVES AND 10 CHANNELS FROM THE SCANNER
20                               IFOR A TOTAL OF 106 COLUMNS OF DATA.
21
22      DIM Scaled(1,106)     IARRAY USED IN PRINTING PROBE & CASCADE PRESSURES
23                               ITD SCREEN
24
25      DIM Prntdata(1,48)    IARRAY USED IN PRINTING BLADE PRESSURES TO SCREEN
26      DIM Prntdatab(1,48)
27
28      MAT Prntdata= (0)      IINITIALLY FILLS ARRAY WITH ZEROS-IF ENTIRE ARRAY
29                               IIS NOT FILLED WITH DATA, THEN REMAINDER OF ARRAY
30                               IWILL CONTAIN ZEROS.
31
32      MAT Prntdatab= (0)
33
34      I..... VARIABLES .....
35
36      Dport=1               IDESIRED PORT. IT IS DESIRED THAT THE SCANIVALVE
37                               IBEGIN AT PORT 1.
38
39      Hport=14              IHIGH PORT. LAST PORT ON THE SCANIVALVE THAT IS
40                               IOF INTEREST.
41
42      Dporta=1             ISAME AS ABOVE EXCEPT IT PERTAINS TO SCANIVALVE
43                               IPRESERVED FOR INSTRUMENTED BLADE SURVEY.
44
45      Hporta=48            IALL PORT USED ON THE BLADE SURVEY
46      Dportb=1            IIN TWO PROBE SURVEYS, MORE PORTS ARE USED-THE
47                               IDESIRED PORT IS STILL 1.
48
49      Hportb=19           ILAST PORT OF INTEREST FOR TWO-PROBE SURVEYS.
50
51      Scntempchn=10        IScanner CHANNEL ASSIGNED TO THERMOCOUPLE
52      Scnyawchn=24         I" " " YAW TRANSDUCER.
53      Scnyawchnl=24       I" " " LOWER PROBE YAW
54                               ITRANSDUCER FOR TWO-PROBE SURVEYS.
55
56      Scnyawchnu=21 17    IScanner CHANNEL ASSIGNED TO UPPER PROBE YAW
57                               ITRANSDUCER FOR TWO-PROBE SURVEYS.
58
59      Scnva=1             ISCANIVALVE USED FOR INSTRUMENTED BLADE.
60      Scnvb=2            I" " " PROBE & CASCADE PRESSURES.
61      Scn=709            IScanner BUS ADDRESS
62      Svc=707            ISCANIVALVE CONTROLLER BUS ADDRESS (H6-78K)
63      Ovm=722            IDIGITAL VOLTMETER BUS ADDRESS
64      Scnrdsvc=1         IScanner CHANNEL ASSIGNED TO READ SCANIVALVE
65                               ICONTROLLER (SCANIVALVE READ IS THE ONE FOR
66                               IPROBE AND CASCADE PRESSURES.)
67
68      Scnrdsvca=0        ISAME AS ABOVE EXCEPT THE SCANIVALVE READ IS FOR
69                               ITHE INSTRUMENTED BLADE PRESSURES
70
71      Scnrdsvcb=1        ISAME AS ABOVE EXCEPT SCANIVALVE READ IS THE
72                               IDONE FOR PROBE & CASCADE PRESSURES WHEN 2-PROBE
73                               IOPTION IS SELECTED.
74
75      Scnstpsvca=40      IScanner CHANNEL ASSIGNED TO STEP SCANIVALVE A
76                               I" " " " " B
77      Scnhmsvca=45      IScanner CHANNEL ASSIGNED TO HOME SCANIVALVE A
78                               I" " " " " B
79      Scnhmsvcb=46      I" " " " " B
80
81      Maxdif=.000050     IERROR TRAP FOR SPURIOUS DVM READINGS.
82
83      Printr=701         IBUS ADDRESS FOR PRINTER
84      Screen=1          IBUS ADDRESS FOR MONITOR
85
86      LOADSUB ALL FROM "/CLASSICK/ROUTINES/SUBACQUIRE"
87
88      MASS STORAGE IS "/CLASSICK/DATA" IALLWS RAW DATA FILE NAME TO BE ENTERED
89                               IAT THE PROMPT WITHOUT PATHNAME
90
91      PRINT "....."
92      PRINT ""
93
94      PRINT "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE PROBE(S)"
95      INPUT Rawfiles$
96
97      CREATE BOAT Rawfiles$,100,848 IRAWFILES$ IS A STRING VARIABLE ASSIGNED
98                               ITO THE RAWFILE NAME TO BE ENTERED AT THE PROMPT.
99      ITHIS FILE IS 100 RECORDS (ENOUGH FOR 100 DATA
100      IPOINTS) EACH RECORD CAN CONTAIN 106 REAL

```

```

127                                INUMBERS 8X105=848.
128 ASSIGN @Path1 TO Rawfile$      IASSIGNS A PATH NAME TO THE RAW FILE JUST
129                                ICREATED FOR ENTER AND OUTPUT STATEMENTS.
130 MASS STORAGE IS "/CLASSICK/REDDATA"
132 PRINT "....."
133 PRINT ""
134 PRINT "NAME FILE TO STORE THE RAW DATA SCALED TO ENGINEERING UNITS"
135 INPUT ScIfile$
136 CREATE BDAT ScIfile$,100,848
137 ASSIGN @Peth2 TO ScIfile@
138 PRINT "....."
139 PRINT ""
140 PRINT "ENTER THE ATMOSPHERIC PRESURE IN INCHES H5"
141 INPUT Pbaro
142 PRINT ""
143 PRINT "....."
144 PRINT ""
145 PRINT "PRESS ""ONE PROBE"" IF ONE PROBE IS USED."
146 PRINT "PRESS ""TWO PROBES"" IF TWO PROBES ARE USED."
147 PRINT ""
148 PRINT "....."
149 PRINT ""
150 ON KEY 1 LABEL "ONE      PROBE" GOTO Numberprbs1 ICODING FOR SOFT KEYS
151 ON KEY 4 LABEL "TWO      PROBES" GOTO Numberprbs2
152 Spin1:      GOTO Spin1                      IKEEPS SOFT KEY LABELS ON SCREEN UNTIL
153                                         I EITHER SOFT KEY IS PRESSED.
154 Numberprbs1: Noofprbs=1                      INUMBER OF PROBES DETERMINES WHERE TO
155                                         I60 IN THE PROGRAM.
157      GOTO Checknoofprbs
158 Numberprbs2: Noofprbs=2
159 Checknoofprbs: IF Noofprbs=2 THEN
160 Start2prbs: INPUT "ENTER THE SCAN NUMBER, LOWER PROBE POSITION AND UPPER P
ROBE POSITION",Scan,Posit1,Positu
161 ELSE
162 Start1prb:INPUT "ENTER THE SCAN NUMBER AND PROBE POSITION",Scan,Posit
163 PRINT ""
164 PRINT "....."
165 END IF
166 COM /Positvrb1/ Svc,Scn                      ICOMMON BLOCK VARIABLES USED IN POSITIONING
167                                         I THE SCANIVALVE PORTS.
169 COM /Readvrb1/ Scan,Dvm,Scanvb(1,48),Tempchnrd,Yawchnrd,Scnyawchn,Scntemp
chn,Scnrdsvcb,Scanva(1,48),Scnrdsvc,Noofprbs,Yawchnrdu,Scnrdsvc
170 COM /Readvrb1/ Yawchnrd1,Scnyawchnu,Scnyawchn1,Maxdif
171                                         IABOVE COMMON BLOCK VARIABLES USED IN
172                                         IOBTAINING DVM READINGS.
174 IF Noofprbs=2 THEN
175      GOTO Read2prbs
176 ELSE
177      GOTO Read1prb
178 END IF
179 Read2prbs:PRINT "SCAN NUMBER"iScan
180 PRINT "LOWER PROBE POSITION"iPosit1
181 PRINT "UPPER PROBE POSITION"iPositu
182 PRINT "PORT          VOLTAGE          GAUGE PRESS(INCHES H2o) "
183 MAT Scanvb= (0)
184 FOR Db=Dportb TO Hportb
185     CALL Scnvportposit(Scnvb,Db,Scnhmsvcb,Scnstpsvcb) ICALLS SUBROUTINE
186     ITO POSITION SCANIVALVE PORTS. INITIALLY IT WILL
187     IPOSITION SCANIVALVE TO PORT 1.
189     CALL Readdvm(Db,Scnrdsvcb)                      ICALLS SUBROUTINE TO READ THE
190     I THE SCANIVALVE PORT READINGS ON
191     I THE DVM.
193     Prntdatb(1,1)=Scanvb(1,1)*10000
194     ICONVERTS DVM READINGS TO PRESSURE
195     IVALUES.
196 IF Db>1 THEN Prntdatb(1,Db)=Scanvb(1,Db)*10000-Prntdatb(1,1) IALLOWS
197     IPORT 1 READING TO BE SUBTRACTED

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198                                     IFROM OTHER READINGS.
200 PRINT USING "DD,10X,MD.3DE,10X,MD.3DE";Db,Scanvb(1,Db),Prntdatb(1,Db)
201 NEXT Db
202 CALL Readdvm(Db,ScnyawchnI)          IDb IN THIS CONTEXT ACTS AS A DUMMY
203                                     IVARIABLE. DVM READS THE LOWER PROBE YAW TRANSDUCER.
204 CALL Readdvm(Db,Scnyawchnu)          IUPPER PROBE YAW TRANSDUCER IS READ.
205 PRINT "....."
206 PRINT "LOWER PROBE YAW CHAN READING"  "iYawchnrdI
207 YawI=YawchnrdI*1000                  ITHIS IS WHERE THE REFERENCING
208                                     ICORRECTION FOR THE YAW ANGLE IS MADE
209 PRINT "LDWER PROBE YAW (DEGREES)"     "iYawI
210 PRINT "UPPER PROBE YAW CHAN READING"  "iYawchnrdu
211 Yawu=Yawchnrdu*1000                  IMAKE THE REFERENCING CORRECTION FOR
212                                     IUPPER PROBE YAW ANGLE HERE.
213
215 PRINT "UPPER PROBE YAW (DEGREES)"     "iYawu
216 GOTO Continue
217 Readlprb:PRINT "SCAN NUMBER";iScan    ICODING FOR READING ONE PROBE BEGINS
218 PRINT "PROBE POSITION";iPosIt
219 PRINT "PORT          VOLTAGE          GUAGE PRESSURE(INCHES H2o)"
220 MAT Scanvb= (0)
221 FOR D=Dport TO Hport
222     CALL Scnvpportposit(Scnvb,D,Scnhmsvcb,Scnstpsvcb) ICALLS SUBROUTINE TO
223                                     IPPOSITION SCANIVALVE PORT.
225     CALL Readdvm(D,Scnrdsvc)          ICALLS SUBROUTINE TO READ SCANIVALVE PORTS
226                                     ION THE DVM.
228     Prntdatb(1,1)=Scanvb(1,1)*10000    ISCALES DVM READINGS TO
229                                     ITO ENGINEERING UNITS.
231 IF D>I THEN Frntdatb(1,D)=Scanvb(1,D)*10000-Frntdatb(1,1) IPORT I
232     ^                                IREADING SUBTRACTED OFF THE SCANIVALVE
233     ^                                IPORT READINGS.
235 PRINT USING "DD,10X,MD.3DE,10X,MD.3DE";D,Scanvb(1,D),Prntdatb(1,D)
236 NEXT D
237 PRINT "....."
238 CALL Readdvm(D,Scnyawchn)
239 PRINT "YAW CHAN READING"              "iYawchnrd
240 Yaw=Yawchnrd*1000                    ITHIS IS WHERE TO CORRECT FOR PROBE YAW REFERENCING
241 PRINT "YAW (DEGREES)"                 "iYaw
242 Continue:CALL Readdvm(Db,Scntempchn)
243 PRINT "TEMP CHAN READING"             "iTempchnrd
244 T=Tempchnrd*1000
245 Temp=33.91*T+34.25+460                IIRON CONSTANIAN THERMOCOUPLE EQUATION
246                                     ISAME ONE USED BY DREON.
248 PRINT "TEMPERATURE (DEGREES R)"       "iTemp
249 Pa=Pbaro*13.57                        IATMOSPHERIC PRESS CONVERTED TO INCHES H2o
250 PRINT USING "26A,4X,2D.2D,X,4A,5X,3D.2D,5A";"ATMOSPHERIC PRESS (INCHES)",P
baro,"(Hg)",Pa,"(H2o)"
251 PRINT ""
252 PRINT "....."
253 PRINT ""
254 PRINT "IS DATA OK? PRESS ""RECORD"" TO RECORD DATA, PRESS ""REPEAT"" TO"
255 PRINT "REPEAT THE SCAN."
256 PRINT ""
257 PRINT "....."
258 ON KEY 1 LABEL "RECORD" GOTO Storerawdata
259 ON KEY 4 LABEL "REPEAT" GOTO Repeatscan
260 Spin2: GOTO Spin2
261 Repeatscan: IF Noofprbs=2 THEN
262     GOTO Start2prbs
263 ELSE
264     GOTO Start1prb
265 END IF
266 Storerawdata: I STORE RAWDATA TO RAWDATA FILE
267 IF Noofprbs=2 THEN
268 MAT Rawdat= (0)
269 FOR K=1 TO 19
270     Rawdat(1,K)=Scanvb(1,K)          IASSIGN ALL THE SCANIVALVE READINGS IN THE

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271                                     ISCANVB ARRAY TO THE RAWDAT ARRAY ELEMENT
272                                     _
273                                     IBY ELEMENT
274     NEXT K
275     Rawdat(1,20)=Posit1
276     Rawdat(1,21)=Positu
277     Rawdat(1,22)=Yawchnrd1
278     Rawdat(1,23)=Yawchnrdu
279     Rawdat(1,24)=Tempchnrd
280     Rawdat(1,25)=Pa
281     OUTPUT @Path1,Scan1Rawdat(*)           I THE DATA IS STORED IN THE RAW DATA
282                                             I FILE WHICH WAS PREVIOUSLY CREATED.
283                                             I THIS IS A RANDOM OUTPUT STATEMENT.
284
285     MAT Scaled= (0)
286     FOR K=1 TO 19
287     Scaled(1,K)=Prntdatb(1,K)             ISAME METHOD HERE EXCEPT SCALED DATA
288                                             I IS REASSIGNED.
289
290     NEXT K
291     Scaled(1,20)=Posit1
292     Scaled(1,21)=Positu
293     Scaled(1,22)=Yaw1
294     Scaled(1,23)=Yawu
295     Scaled(1,24)=Temp
296     Scaled(1,25)=Pa
297     OUTPUT @Path2,Scan1Scaled(*)
298     ELSE
299     MAT Rawdat= (0)
300     FOR K=1 TO 14                         IFOR THE ONE PROBE OPTION, ASSIGNS
301                                             I ALL THE SCANIVALVE READINGS IN THE
302                                             I ARRAY TO THE RAWDAT ARRAY ELEMENT
303                                             I BY ELEMENT.
304
305     Rawdat(1,K)=Scanvb(1,K)
306     NEXT K
307     Rawdat(1,15)=Posit
308     Rawdat(1,16)=Yawchnrd
309     Rawdat(1,17)=Tempchnrd
310     Rawdat(1,18)=Pa
311     OUTPUT @Path1,Scan1Rawdat(*)           I THE DATA IS STORED IN THE RAW DATA
312                                             I WHICH WAS PREVIOUSLY CREATED. THIS
313                                             I IS A RANDOM OUTPUT STATEMENT.
314
315     MAT Scaled= (0)
316     FOR K=1 TO 14
317     Scaled(1,K)=Prntdatb(1,K)             ISAME METHOD HERE EXCEPT SCALED DATA
318                                             I IS REASSIGNED.
319
320     NEXT K
321     Scaled(1,15)=Posit
322     Scaled(1,16)=Yaw
323     Scaled(1,17)=Temp
324     Scaled(1,18)=Pa
325     OUTPUT @Path2,Scan1Scaled(*)
326     END IF
327     PRINT "....."
328     PRINT ""
329     PRINT "PRESS ""GO ON"" TO CONTINUE TAKING DATA, PRESS ""END PRB DATA""
330     PRINT "TO TERMINATE PROBE DATA COLLECTION."
331     PRINT ""
332     PRINT "....."
333     ON KEY 1 LABEL "END PRB DATA" GOTO Printfilename
334     ON KEY 4 LABEL "GO ON" GOTO Collectdata
335     Spin3: GOTO Spin3
336     Collectdata: IF Noofprbs=2 THEN
337         GOTO Start2prbs
338     ELSE
339         GOTO Start1prb
340     END IF
341     PRINT "....."
342     PRINT ""

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343 Printfilename: PRINT "RAW PROBE DATA IS STORED "
344 PRINT "IN DATA FILE",Rawfile$ "
345 PRINT ""
346 PRINT "....."
347 PRINT ""
348 PRINT "PROBE RAW DATA SCALED TO ENGINEERING UNITS"
349 PRINT "IS STORED IN REDDATA FILE",Scifile$
350 PRINT ""
351 PRINT "....."
352 PRINT ""
353 PRINT "ENSURE THE PROBE IS CLEAR OF THE INSTRUMENTED BLADE."
354 PRINT ""
355 PRINT "....."
356 PRINT ""
357 PRINT " PRESS ""COLLECT DATA"" TO COLLECT DATA FOR THE INSTRUMENTED BLADE"
358 PRINT " PRESS ""GO ON"" TO CONTINUE WITH THE PROGRAM."
359 PRINT ""
360 ON KEY 4 LABEL "GO ON" GOTO Printoption1
361 ON KEY 1 LABEL "COLLECT DATA" GOTO Namefile
362 Spin4: GOTO Spin4
363 Namefile: MASS STORAGE IS "/CLASSICK/DATA" ICODING FOR INSTRUMENTED
364 IBLADE SECTION OF PROGRAM IS SAME AS FOR
IPROBE SECTION.
366 PRINT "....."
367 PRINT ""
368 PRINT "NAME FILE FOR THE RAW DATA TO BE COLLECTED FROM THE BLADE."
369 INPUT Rawbladfile$
370 CREATE 80AT Rawbladfile$,100,384 1100 RECORDS, EACH RECORD CAN CONTAIN
371 148 REAL NUMBERS 8X48=384.
373 ASSIGN @Path3 TO Rawbladfile$
374 MASS STORAGE IS "/CLASSICK/REDDATA"
375 PRINT "....."
376 PRINT ""
377 PRINT "NAME FILE FOR THE RAW BLADE DATA SCALED TO ENGINEERING UNITS."
378 INPUT Scibladfile$
379 PRINT ""
380 PRINT "....."
381 CREATE 80AT Scibladfile$,100,384
382 ASSIGN @Path4 TO Scibladfile$
383 Bladeread: MAT Scanva=(0)
384 PRINT "SCAN NUMBER",Scan
385 PRINT "PORT VOLTAGE GUAGE PRESS(INCHES H2o)"
386 FOR Oa=0ports TO Hports
387 CALL Scnsvportposit(Scnva,Oa,Scnhmsvca,Scnstpsvca)
388 CALL Readdvm(Da,Scnrdsvca)
389 Prntdata(1,Oa)=Scanva(1,Oa)*10000
390 IF Da>1 THEN Prntdata(1,Oa)=Scanva(1,Oa)*10000-Prntdata(1,1)
391 PRINT USING "00,10X,MD.3DE,10X,MD.30E"iOa,Scanva(1,Oa),Prntdata(1,Oa)
392 NEXT Oa
393 PRINT "....."
394 PRINT ""
395 PRINT "IS DATA OK? PRESS ""REPEAT"" TO REPEAT THE SCAN, PRESS ""RECORD""
396 PRINT "TO RECORD THE DATA."
397 PRINT ""
398 PRINT "....."
399 ON KEY 1 LABEL "RECORD" GOTO Storedata
400 ON KEY 4 LABEL "REPEAT" GOTO Bladeread
401 Spin5: GOTO Spin5
402 Storedata: OUTPUT @Path3,Scanva(*)
403 OUTPUT @Path4,Prntdata(*)
404 PRINT "THIS DATA IS ASSOCIATED WITH THE LAST SCAN OF FILE ",Scifile$
405 PRINT ""
406 Printoption1: PRINT "....."
407 PRINT ""
408 PRINT "ALIGN PAPER IN PRINTER. "
409 PRINT ""

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410 PRINT "TO PRINT OUT A TABULATION OF THE RAW DATA COLLECTED FROM"
411 PRINT ""
412 PRINT "THE PROBE(S), PRESS ""RAW TABLE"". PRESS ""GO ON""
413 PRINT ""
414 PRINT "TO CONTINUE WITH THE PROGRAM."
415 PRINT ""
416 PRINT "....."
417 ON KEY 1 LABEL "RAW      TABLE" GOTO Printrawtable
418 ON KEY 4 LABEL "GO ON" GOTO Prinoption2
419 Spin6: GOTO Spin6
420 Printrawtable: MASS STORAGE IS "/CLASSICK/ATA"
421 ASSIGN @Path1 TO Rawfile$      ISTATEMENT PUTS FILE POINTER AT BEGINING
422                                IOF FILE.
424 PRINT ""
425 PRINT "PRESS ""ONE PROBE"" IF ONE PROBE WAS USED."
426 PRINT "PRESS ""TWO PROBES"" IF TWO PROBES WERE USED."
427 PRINT ""
428 PRINT "....."
429 ON KEY 1 LABEL "ONE      PROBE" GOTO Numberofprbs1
430 ON KEY 4 LABEL "TWO      PROBES" GOTO Numberofprbs2
431 Spin7: GOTO Spin7
432 Numberofprbs1: Noofprbs=1
433 GOTO Howmanyprbs
434 Numberofprbs2: Noofprbs=2
435 Howmanyprbs:      IF Noofprbs=2 THEN
436 PRINTER IS Prnter      ISENOS PRINT STATEMENTS TO THE PRINTER.
437 PRINT "....."
438 PRINT "PROBE RAW DATA FILE      ",Rawfile$
439 PRINT "....."
440 PRINT "SCAN  L PRB      1      2      3      4
5"
441 PRINT "      POSIT"
442 FOR N=1 TO 100
443 ENTER @Path1,N,Rawdat(*)      ISTATEMENT ACCESSES THE RAW DATA FILE IN
444                                IRANOOM MODE.
445 ON END @Path1 GOTO Twoprintrawl      ISINCE ALL RECORDS OF A FILE MAY
446                                INOT BE FILLED (RECALL 100 RECORDS WERE
447                                IRESERVED FOR 100 DATA POINTS), THE ON
448                                IEND STATEMENT ALLOWS THE PROGRAM TO
449                                ICONTINUE AT THE Twoprintrawl LINE WHEN
450                                IAN END OF FILE CONDITION OCCURS.
451
453 Posit1=Rawdat(1,20)
454 Port1=Rawdat(1,1)
455 Port2=Rawdat(1,2)
456 Port3=Rawdat(1,3)
457 Port4=Rawdat(1,4)
458 Port5=Rawdat(1,5)
459 PRINT USING "40,3X,40.20,3X,MD.30E,3X,MD.30E,3X,NO.30E,3X,NO.30E,3X,NO.30E"
IN,Posit1,Port1,Port2,Port3,Port4,Port5
460 NEXT N
461 Twoprintrawl: PRINT "....."
....."
462 PRINT "SCAN  6      7      8      9      10
11"
463 FOR N=1 TO 100
464 ENTER @Path1,N,Rawdat(*)
465 ON END @Path1 GOTO Twoprintraw2
466 Port6=Rawdat(1,6)
467 Port7=Rawdat(1,7)
468 Port8=Rawdat(1,8)
469 Port9=Rawdat(1,9)
470 Port10=Rawdat(1,10)
471 Port11=Rawdat(1,11)
472 PRINT USING "40,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E,2X,NO.30E,2X,MD.30E"
IN,Port6,Port7,Port8,Port9,Port10,Port11
473 NEXT N

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474 Twoprintraw2: FRINT "....."
....."
475 PRINT "SCAN   U PRB      12      13      -      14      15
16"
476   FRINT "      POSIT"
477   FOR N=1 TO 100
478   ENTER @Path1,NiRawdat(*)
479   DN ENO @Path1 60TD Twoprintraw3
480   Positu=Rawdat(1,21)
481   Port12=Rawdat(1,12)
482   Port13=Rawdat(1,13)
483   Port14=Rawdat(1,14)
484   Port15=Rawdat(1,15)
485   Port16=Rawdat(1,16)
486   PRINT USING "4D,3X,40.2D,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E"
iN,Positu,Port12,Port13,Port14,Port15,Port16
487   NEXT N
488 Twoprintraw3: PRINT "....."
....."
489   FRINT "SCAN      17      18      19 "
490   FOR N=1 TO 100
491   ENTER @Path1,NiRawdat(*)
492   ON END @Path1 60TD Twoprintraw4
493   Port17=Rawdat(1,17)
494   Port18=Rawdat(1,18)
495   Port19=Rawdat(1,19)
496   Pa=Rawdat(1,25)
497   PRINT USING "4D,3X,MD.30E,4X,MD.30E,4X,MD.30E"iN,Port17,Port18,Port19
498   NEXT N
499 Twoprintraw4: PRINT "....."
....."
500   FRINT "SCAN   YAW L      YAW U      TEMPCHN      ATMOS"
501   PRINT "      VOLT      VOLT      VOLT      PRESSURE"
502   FOR N=1 TO 100
503   ENTER @Path1,NiRawdat(*)
504   ON ENO @Path1 60TD Twoprintraw5
505   Yawchnrd1=Rawdat(1,22)
506   Yawchnrdu=Rawdat(1,23)
507   Tempchnrd=Rawdat(1,24)
508   Pa=Rawdat(1,25)
509   PRINT USING "4D,3X,MD.30E,4X,MD.30E,4X,MD.30E,4X,3D.2D"iN,Yawchnrd1,Yawchnr
du,Tempchnrd,Pa
510   NEXT N
511 Twoprintraw5: OFF ENO @Path1      I TERMINATES THE ON ENO COMMAND
512   ELSE
513   PRINTER IS Prnter
514   PRINT "....."
515   PRINT "PROBE RAW DATA FILE  ",Rawfile$
516   PRINT "....."
517   PRINT "SCAN   PROBE      1      2      3      4      5"
518   PRINT "      POSIT"
519   FOR N=1 TO 100
520   ENTER @Path1,NiRawdat(*)      I STATEMENT ACCESSES THE RAW DATA FILE IN
521   IRANODM MODE
522   DN ENO @Path1 60TD Printrawl      I SINCE ALL RECDROS OF A FILE MAY NOT BE
523   IFILLED (RECALL 100 WERE USED FOR 100
524   IOATA POINTS), ON END STATEMENT ALLOWS THE
525   IPROGRAM TO CONTINUE AT THE Printrawl LINE
526
527   Posit=Rawdat(1,15)
528   Port1=Rawdat(1,1)
529   Port2=Rawdat(1,2)
530   Port3=Rawdat(1,3)
531   Port4=Rawdat(1,4)
532   Port5=Rawdat(1,5)
533
534   PRINT USING "4D,2X,4D.2D,2X,MD.30E,2X,MD.30E,2X,MD.30E,2X,MD.30E,2X,MD.30E
",N,Posit,Port1,Port2,Port3,Port4,Port5

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535 NEXT N
536 Printraw1: PRINT "....."
537 PRINT "SCAN 6          7          8          9          10          11
-
538 FOR N=1 TO 100
539 ENTER @Path1,N,Rawdat(*)
540 ON ENO @Path1 60TO Printraw2
541 Port6=Rawdat(1,6)
542 Port7=Rawdat(1,7)
543 Port8=Rawdat(1,8)
544 Port9=Rawdat(1,9)
545 Port10=Rawdat(1,10)
546 Port11=Rawdat(1,11)
547 PRINT USING "40,2X,MO.30E,2X,MO.30E,2X,MO.30E,2X,MO.30E,2X,MO.30E,2X,MO.30E
",N,Port6,Port7,Port8,Port9,Port10,Port11
548 NEXT N
549 Printraw2: PRINT "....."
550 PRINT "SCAN 12          13          14          YAWCHAN      TEMPCHAN      AT
MOS"
551 PRINT "          VOLTAGE      VOLTAGE      PR
ESSURE"
552 FOR N=1 TO 100
553 ENTER @Path1,N,Rawdat(*)
554 ON ENO @Path1 60TO Printraw3
555 Port12=Rawdat(1,12)
556 Port13=Rawdat(1,13)
557 Port14=Rawdat(1,14)
558 Yawchnrd=Rawdat(1,16)
559 Tempchnrd=Rawdat(1,17)
560 Pa=Rawdat(1,18)
561 PRINT USING "40,2X,MO.30E,2X,MO.30E,2X,MO.30E,2X,MO.30E,2X,MO.30E,2X,30.20"
",N,Port12,Port13,Port14,Yawchnrd,Tempchnrd,Pa
562 NEXT N
563 Printraw3: PRINT "....."
564 OFF ENO @Path1          I TERMINATES ON ENO STATEMENT
565 ENO IF
566 PRINTER IS Screen          I RETURNS PRINT STATEMENTS TO MONITOR.
567 PRINT "....."
568 PRINT ""
569 Printoption2: PRINT "ALIGN PAPER IN PRINTER."
570 PRINT ""
571 PRINT "TO PRINTOUT A TABULATION OF THE PROBE DATA SCALED IN"
572 PRINT ""
573 PRINT "ENGINEERING UNITS, PRESS ""SCALED DATA""."
574 PRINT ""
575 PRINT "PRESS ""60 ON"" TO CONTINUE WITH THE PROGRAM."
576 PRINT ""
577 PRINT "....."
578 ON KEY 1 LABEL " SCALED DATA" 60TO Prntscaledtable
579 ON KEY 4 LABEL "60 ON" 60TO Printoption3
580 Spin8: 60TO Spin8
581 Prntscaledtable: MASS STORAGE IS "/CLASSICK/REO0ATA"
582 ASSIGN @Path2 TO Sc1file$
583 PRINT ""
584 PRINT "PRESS ""ONE PROBE"" IF ONE PROBE WAS USED."
585 PRINT "PRESS ""TWO PROBES "" IF TWO PROBES WERE USED."
586 PRINT ""
587 PRINT "....."
588 ON KEY 1 LABEL "ONE PROBE" 60TO Numberprobes1
589 ON KEY 4 LABEL "TWO PROBES" 60TO Numberprobes2
590 Spin9: 60TO Spin9
591 Numberprobes1: Noofprbs=1
592 60TO Howmanyprobes

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593 Numberprobes2: Noofprbs=2
594 Howmanyprobes:      IF Noofprbs=2 THEN      -
595 PRINTER IS Printer
596 PRINT "....."
597 PRINT "PROBE SCALED DATA FILE  ",Scifile$
598 PRINT "....."
599 PRINT "SCAN  L PRB      1          2          3          4
5"
600 PRINT "      POSIT"
601   FOR N=1 TO 100
602     ENTER @Fath2,NiScaled(*)
603   ON END @Fath2 6010 Twoprintsc11
604     Posit1=Scaled(1,20)
605     Port1=Scaled(1,1)
606     Port2=Scaled(1,2)
607     Port3=Scaled(1,3)
608     Port4=Scaled(1,4)
609     Port5=Scaled(1,5)
610   PRINT USING "40,3X,40.20,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E"
iN,Posit1,Port1,Port2,Port3,Port4,Port5
611 NEXT N
612 Twoprintsc11: PRINT "....."
613 PRINT "SCAN  6          7          8          9          10
11"
614   FOR N=1 TO 100
615     ENTER @Fath2,NiScaled(*)
616   ON END @Fath2 6010 Twoprintsc12
617     Port6=Scaled(1,6)
618     Port7=Scaled(1,7)
619     Port8=Scaled(1,8)
620     Port9=Scaled(1,9)
621     Port10=Scaled(1,10)
622     Port11=Scaled(1,11)
623   PRINT USING "40,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E,2X,MD.30E,2X,MD.30E"
iN,Port6,Port7,Port8,Port9,Port10,Port11
624 NEXT N
625 Twoprintsc12: PRINT "....."
626 PRINT "SCAN  U PRB      12          13          14          15
16"
627 PRINT "      POSIT"
628   FOR N=1 TO 100
629     ENTER @Fath2,NiScaled(*)
630   ON END @Fath2 6010 Twoprintsc13
631     Positu=Scaled(1,21)
632     Port12=Scaled(1,12)
633     Port13=Scaled(1,13)
634     Port14=Scaled(1,14)
635     Port15=Scaled(1,15)
636     Port16=Scaled(1,16)
637   PRINT USING "40,3X,40.20,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E,3X,MD.30E"
iN,Positu,Port12,Port13,Port14,Port15,Port16
638 NEXT N
639 Twoprintsc13: PRINT "....."
640 PRINT "SCAN  17          18          19 "
641   FOR N=1 TO 100
642     ENTER @Fath2,NiScaled(*)
643   ON END @Fath2 6010 Twoprintsc14
644     Port17=Scaled(1,17)
645     Port18=Scaled(1,18)
646     Port19=Scaled(1,19)
647   PRINT USING "40,3X,MD.30E,4X,MD.30E,4X,MD.30E"iN,Port17,Port18,Port19
648 NEXT N
649 Twoprintsc14: PRINT "....."

```

```

650 PRINT "SCAN   YAW L           YAW U           TEMP           ATMS"
651 PRINT "      DEG           DEG           (R)           PRESSURE"
652 FOR N=1 TO 100
653 ENTER @Path2,N;Scaled(*)
654 DN END @Path2 GOTO Twoprintsc15
655 YawL=Scaled(1,22)
656 YawU=Scaled(1,23)
657 Temp=Scaled(1,24)
658 Pa=Scaled(1,25)
659 PRINT USING "4D,3X,MD.3DE,4X,MD.3DE,4X,MD.3DE,4X,3D.2D" iN,YawL,YawU,Temp,Pa
660 NEXT N
661 Twoprintsc15: DFF END @Path2
662             ELSE
663             I END IF
664 PRINTER IS Prnter
665 PRINT "....."
666 PRINT "PRDBE SCALED DATA FILE   ",Scfile$
667 PRINT "....."
668 PRINT "SCAN   PRDBE           1           2           3           4
5"
669 PRINT "           POSIT"
670 FOR N=1 TO 100
671 ENTER @Path2,N;Scaled(*)
672 DN END @Path2 GOTO Printsc11
673 Posit=Scaled(1,15)
674 Port1=Scaled(1,1)
675 Port2=Scaled(1,2)
676 Port3=Scaled(1,3)
677 Port4=Scaled(1,4)
678 Port5=Scaled(1,5)
679 PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE
"N,Posit,Port1,Port2,Port3,Port4,Port5
680 NEXT N
681 Printsc11: PRINT "....."
682 PRINT "SCAN   6           7           8           9           10           11
"
683 FOR N=1 TO 100
684 ENTER @Path2,N;Scaled(*)
685 DN END @Path2 GOTO Printsc12
686 Port6=Scaled(1,6)
687 Port7=Scaled(1,7)
688 Port8=Scaled(1,8)
689 Port9=Scaled(1,9)
690 Port10=Scaled(1,10)
691 Port11=Scaled(1,11)
692 PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE
"N,Port6,Port7,Port8,Port9,Port10,Port11
693 NEXT N
694 Printsc12: PRINT "....."
695 PRINT "SCAN   12           13           14           YAW           TEMP           AT
MOS"
696 PRINT "           DEG           (R)           PR
ESS"
697 FOR N=1 TO 100
698 ENTER @Path2,N;Scaled(*)
699 DN END @Path2 GOTO Printsc13
700 Port12=Scaled(1,12)
701 Port13=Scaled(1,13)
702 Port14=Scaled(1,14)
703 Yaw=Scaled(1,16)
704 Temp=Scaled(1,17)
705 Pa=Scaled(1,18)
706 PRINT USING "4D,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,MD.3DE,2X,3D.2D"

```

```

iN,Port12,Port13,Port14,Yaw,Temp,Pa
707 NEXT N
708 PrintscI3: PRINT "....."
709 OFF ENO @Path2
710 ENO IF
711 PRINTER IS Screen
712 PRINT "....."
713 PRINT ""
714 Printoption3: PRINT "PRESS ""BLADE DATA"" FOR BLADE DATA PRINT OPTIONS."
715 PRINT ""
716 PRINT "PRESS ""GO ON"" TO CONTINUE PROGRAM."
717 PRINT ""
718 PRINT "....."
719 ON KEY 1 LABEL "BLADE DATA" GOTO Printoption4
720 ON KEY 4 LABEL "GO ON" GOTO Loadoption1
721 Spin10: GOTO Spin10
722 Printoption4: PRINT ""
723 PRINT "ALIGN PAPER IN PRINTER."
724 PRINT ""
725 PRINT "TO PRINT OUT A TABULATION OF THE RAW BLADE DATA"
726 PRINT ""
727 PRINT "PRESS ""BLADE DATA"". PRESS ""GO ON"" TO CONTINUE."
728 PRINT ""
729 PRINT "....."
730 ON KEY 1 LABEL "BLADE DATA" GOTO Printbladedata
731 ON KEY 4 LABEL "GO ON" GOTO Printoption5
732 Spin11: GOTO Spin11
733 Printbladedata: MASS STORAGE IS "/CLASSICK/DA"
734 ASSIGN @Path3 TO Rawbladfile$
735 PRINTER IS Printer
736 PRINT "....."
737 PRINT "BLADE RAW DATA FILE ",Rawbladfile$
738 PRINT "....."
739 PRINT ""
740 PRINT "PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED"
741 PRINT "IN FILE: ",Rawfile$
742 PRINT "SCAN:",Scan
743 PRINT "SCANIVALUE VOLTAGE"
744 PRINT "FORT READING"
745 FOR N=1 TO 48
746 ENTER @Path3,Scanva(1,N)
747 PRINT USING "0D,20X,MD.3DE" iN,Scanva(1,N)
748 NEXT N
749 PRINTER IS Screen
750 Printoption5: PRINT "....."
751 PRINT ""
752 PRINT "ALIGN PAPER IN PRINTER."
753 PRINT ""
754 PRINT "TO PRINT OUT A TABULATION OF THE BLADE DATA SCALED TO "
755 PRINT ""
756 PRINT "ENGINEERING UNITS, PRESS ""SCALED DATA"". "
757 PRINT ""
758 PRINT "PRESS ""GO ON"" TO TERMINATE PROGRAM."
759 PRINT ""
760 ON KEY 1 LABEL "SCALED DATA" GOTO Printscldbladdat
761 ON KEY 4 LABEL "GO ON" GOTO Loadoption1
762 Spin12: GOTO Spin12
763 Printscldbladdat: MASS STORAGE IS "/CLASSICK/REDDATA"
764 ASSIGN @Path4 TO ScIbladfile$
765 PRINTER IS Printer
766 PRINT "....."
767 PRINT "BLADE SCALED DATA FILE ",ScIbladfile$
768 PRINT "....."

```

```

769      PRINT ""
770      PRINT "PROBE DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED"
771      PRINT "IN FILE: ",Scifile$
772      PRINT "SCAN:",Scan
773      PRINT "SCANIVALVE          PRESS (INCHES H2O)"
774      PRINT "PORT"
775      FOR N=1 TO 48
776      ENTER @Path4;Prntdata(1,N)
777      PRINT USING "DD,20X,M0.3DE";N,Prntdata(1,N)
778      NEXT N
779 Loadoption1:  PRINTER IS Screen
780      PRINT "....."
781      PRINT ""
782      PRINT "TO LOAD PROGRAM TO REDUCE THE ACQUIRED DATA"
783      PRINT ""
784      PRINT "PRESS ""CALC"", PRESS ""GO ON"" TO TERMINATE THE PROGRAM"
785      PRINT ""
786      PRINT "....."
787      ON KEY 1 LABEL "CALC" GOTO Loadup1
788      ON KEY 4 LABEL "GO ON" GOTO Fin
789 Spin13:      GOTO Spin13
790 Loadup1: MASS STORAGE IS "/CLASSICK/PROGS"
791      LOAD "CALC",10
792 Fin: PRINT "....."
793      PRINT "....."
794      PRINT ""
795      PRINT "          END OF PROGRAM"
796      PRINT ""
797      PRINT "....."
798      PRINT "....."
799      ENO

```

B7.2 Reduction Program CALC

```

10  IPROGRAM CALC
20  I THIS PROGRAM TAKES THE FILES OF DATA COLLECTED FROM THE PROBE(S)
30  I AND REDUCES THE DATA TO USEFUL ENGINEERING QUANTITIES THESE
40  I VALUES ARE PRINTED IN TABLE FORM.
41  IMUCH OF THE CODING IN THIS PROGRAM HAS BEEN PREVIOUSLY COMMENTED ON
42  IIN PROGRAM ACQUIRE.
50  OPTION BASE I
70  DIM Reddat(1,105)          !AN ARRAY FOR THE SCALED DATA FROM ACQUIRE.
71                               !RECALL THAT THE SCALED DATA WAS STORED BY
72                               !A RANDOM OUTPUT STATEMENT.
80  DIM P(6,6)                !THE ARRAY FOR THE PHI COEFFICIENTS.
90  DIM X(6,6)                !THE ARRAY FOR THE X VELOCITY COEFFICIENTS.
91  DIM Pu(6,6)               !IF 2 PROBES USED THEN THE PHI ARRAY FOR
92                               !THE UPPER PROBE.
94  DIM Xu(6,6)
95  DIM Karray(100)           !KN VALUES STORED IN AN ARRAY.Kn=K IN TABLE
96                               !I OF CLASSICK THESIS.
98  DIM Prbpos(100)
99  DIM Aarray(100)           !AN ARRAY OF VALUES USED IN THE CALCULATION
101  DIM Barray(100)           !OF BLADE CP'S.
102  MAT Reddat= (0)
103  MAT Karray= (0)
104  MAT Prbpos= (0)
105  MAT Aarray= (0)
106  MAT Barray= (0)
107  DEG                      !ALL ANGLES WILL BE IN DEGREES.
108  Prnter=701
109  Screen=1
110  Firstbladeprnt=4         !FIRST SCANIVALVE PORT ASSIGNED TO THE
111                               !INSTRUMENTED BLADE THAT IS OF INTEREST
112                               !IN THE CP CALCULATION.
114  Lastbladeprnt=48         !LAST " " "ect.
115  G=1.4
116  Cp=.24
120  LOADSUB ALL FROM "/CLASSICK/ROUTINES/SUBCALC"
130  MASS STORAGE IS "/CLASSICK/REDOATA"
131  PRINT "....."
132  PRINT ""
134  PRINT "ENTER THE NAME OF THE FILE CONTAINING THE PROBE DATA SCALED"
135  PRINT "TO ENGINEERING UNITS"
136  INPUT Sc1file$
140  ASSIGN @Path1 TO Sc1file$
141  PRINT "....."
142  PRINT ""
144  PRINT "ENTER THE PROBE COEFFICIENT FILE FOR X VELOCITY. THIS WILL BE "
145  PRINT ""
146  PRINT "FOR THE LOWER PROBE IF TWO PROBES ARE BEING USED."
148  INPUT Readx$
151  ASSIGN @Path2 TO Readx$
160  ENTER @Path2;X(0)
161  PRINT "....."
162  PRINT ""
170  PRINT "ENTER THE NAME OF THE COEFFICIENT FILE FOR PHI. THIS WILL BE "
171  PRINT ""
172  PRINT "FOR THE LOWER PROBE IF TWO PROBES ARE BEING USED."
174  INPUT Readp$
180  ASSIGN @Path3 TO Readp$
190  ENTER @Path3;P(0)
191  PRINT "....."
192  PRINT ""
200  PRINT "IF DATA WERE COLLECTED WITH ONE PROBE, PRESS "" ONE PROBE""
201  PRINT ""
220  PRINT "IF DATA WERE COLLECTED WITH TWO PROBES, PRESS ""TWO PROBES""
221  PRINT ""

```

```

224 PRINT "....."
225 ON KEY 1 LABEL "ONE" PROBE" GOTO Numberprbs1
226 ON KEY 4 LABEL "TWO" PROBES" GOTO Numberprbs2
227 Spin1: GOTO Spin1
228 Numberprbs1: Noofprbs=1
229 GOTO Checknoofprbs
231 Numberprbs2: Noofprbs=2
240 Checknoofprbs: IF Noofprbs=2 THEN
250 MASS STORAGE IS "/CLASSICK/REO0ATA"
251 PRINT "....."
252 PRINT ""
253 PRINT "ENTER THE FILE NAME FOR THE UPPER PROBE COEFFICIENTS FOR Xvel."
254 INPUT Readxu$
255 ASSIGN @Path2u TO Readxu$
256 ENTER @Path2u;Xu(*)
259 PRINT "....."
260 PRINT ""
261 PRINT "ENTER THE FILE NAME FOR THE UPPER PROBE COEFFICIENTS FOR PHI."
262 INPUT Readpu$
263 ASSIGN @Path3u TO Readpu$
264 ENTER @Path3u;Pu(*)
267 PRINT "....."
268 PRINT ""
269 PRINT "ENTER THE FILENAME FOR THE OATA TO BE CALCULATED FROM LOWER PROBE"
270 INPUT Calc1file$
273 CREATE BOAT Calc1file$,100
274 ASSIGN @Path4 TO Calc1file$
275 PRINT "....."
276 PRINT ""
277 PRINT "ENTER THE FILENAME FOR THE OATA TO BE CALCULATED FROM UPPER PROBE"
278 INPUT Calcufile$
281 CREATE BOAT Calcufile$,100
282 ASSIGN @Path5 TO Calcufile$
283 !.....
284 !* NOTE: THE SCANIVALVE SENSES THE PRESSURE DIFFERENTIAL FROM *
285 !* ATMOS. THE SCANIVALVE IS CALIBRATED SO ATMOS PRESS(Pa) *
286 !* READS ZERO. THE PRESS SENSED AT A PORT IS THE PORT *
287 !* PRESS MINUS Pa i.e., GAGE PRESS. TO ELIMINATE ERRORS DUE *
288 !* TO OVM ORIFT, THE PRESS SENSED BY PORT 1 OF THE *
289 !* SCANIVALVE (Ptare=Pa-Pa) IS SUBTRACTED FROM EACH *
290 !* SCANIVALVE PORT READING. *
291 !*
292 !..... TWO PROBES .....
293 !.....SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENT.....
294 !*
295 !*
296 !* VARIABLE VARIABLE PORT CHANNEL DATA ARRAY *
297 !* REPRESENTS *
298 !*
299 !* Ptare Pa-Pa PORT 1 Reddat(1,1) *
300 !* Pcal Pcal-Ptare PORT 2 Reddat(1,2) *
301 !* Pp Pplenum-Ptare PORT 3 Reddat(1,3) *
302 !* Pa Pwallstatic-Ptare PORT 4 Reddat(1,4) *
303 !* P1 P1-Ptare PORT 5 Reddat(1,5) *
304 !* P2 P2-Ptare PORT 6 Reddat(1,6) *
305 !* P3 P3-Ptare PORT 7 Reddat(1,7) *
306 !* P23 (P2+P3)/2 *
307 !* P4 P4-Ptare PORT 8 Reddat(1,8) *
308 !* P5 P5-Ptare PORT 9 Reddat(1,9) *
309 !* Ptp Ptotalprndtl-Ptare PORT 10 Reddat(1,10) *
310 !* Psp Pstatprndtl-Ptare PORT 11 Reddat(1,11) *
311 !* BLANK PORT 12 Reddat(1,12) *
312 !* Plu Plu-Ptare PORT 13 Reddat(1,13) *
313 !* P2u P2u-Ptare PORT 14 Reddat(1,14) *
314 !* P3u P3u-Ptare PORT 15 Reddat(1,15) *
315 !* P23u (P2u+P3u)/2 *

```

```

316 1* P4u      P4u-Ptare      PORT 16      Reddat(1,16)      .
317 1* PSu      PSu-Ptare      PORT 17      Reddat(1,17)      .
318 1*          BLANK          PORT 18      Reddat(1,18)      .
319 1*          BLANK          PORT 19      Reddat(1,19)      .
320 1* Posit     L PRB POSIT     INPUT      Reddat(1,20)      .
321 1* Positu     U PRB POSIT     INPUT      Reddat(1,21)      .
322 1* Yaw       LOWER PRB YAW    24         Reddat(1,22)      .
323 1* Yawu      UPPER PRB YAW    21         Reddat(1,23)      .
324 1* Temp      TOTAL TEMP(PLENUM) CHAN 10      Reddat(1,24)      .
325 1* Pa        ATMOSPHERIC PRESS INPUT      Reddat(1,25)      .
326 1*          .
327 1*          .
328 1*          .
329 1*          .DATA REDUCTION.
330 DIM Calcl(100,25)
331 MAT Calcl= (0)
332 Pinitiall=0
333                                     !INITIALIZES THE CONDITIONS TO CALCULATE
                                     !ENSEMBLE VALUES IN SUBROUTINE ENSEMBLE
335 Tinitial=0
336 Pinitiall=0
337 FOR N=1 TO 100
338 ENTER @Pathl,N,Reddat(*)
339                                     !THE ARRAY IS ENTERED WITH A RANDOM
                                     !STATEMENT.
341 DN END @Pathl 60TD Twoprintcalcl
342 Ptare=Reddat(1,1)
343                                     !REASSIGNMENT OF ARRAY ELEMENTS TO
344                                     !IDENTIFIABLE QUANTITIES TO BE USED IN
                                     !IN SUBROUTINE CALCULATIONS.
346 Pcal=Reddat(1,2)
347 Pp=Reddat(1,3)
348 Ps=Reddat(1,4)
349 Pl=Reddat(1,5)
350 P2=Reddat(1,6)
351 P3=Reddat(1,7)
352 P23=(P2+P3)/2
353 P4=Reddat(1,8)
354 P5=Reddat(1,9)
355 Ptp=Reddat(1,10)
356 Psp=Reddat(1,11)
357 !BLANK=Reddat(1,12)
358 Posit=Reddat(1,20)
359 Yaw=Reddat(1,22)
360                                     !YAW ANGLE CORRECTION COULD BE MADE
                                     !HERE IF NOT ALREADY DONE IN ACQUIRE.
362 Temp=Reddat(1,24)
363 Pa=Reddat(1,25)
364 !CALCULATE BETA AND GAMMA COEFFICIENTS
365 CALL Bgcalc(Pa,Pl,P23,P4,P5,Beta,Gamma)
366 !CALCULATE THE ENSEMBLE REFERENCE VALUES OF PLENUM PRESS,PLENUM TEMP AND PA
367 CALL Ensemble(Pp,Pinitial,Pa,Pinitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
368 !CALCULATE Xvel AND Phi
369 CALL Xphicalc(Beta,Gamma,Xvel,X(*),Phi,P(*))
370 !CALCULATE Xref
371 CALL Xrefcalc(Pa,Pp,6,Xref)
372 !CALCULATE QREF AND VREF
373 CALL Qvrefcalc(Xref,Cp,Temp,6,Pp,Pa,Qref,Uref)
374 !CALCULATE VELOCITY AND MACH # AND Q
375 CALL Vmqcalc(Xvel,Cp,Temp,6,Vel,Mach,Pl,Pa,Q)
376 !CALCULATE THE INTEGRAND FOR THE AVDR EXPRESSION
377 CALL Kncalc(Pa,Pl,Pp,Xvel,Xref,6,Yaw,Kn)
378 !CALCULATE THE COEFFICIENT OF PRESSURE TERM TO BE MASS AVERAGED.
379 !THESE TERMS ARE USED IN THE CALCULATION OF THE LOSS COEFFICIENT.
380 CALL Coefpress(Pl,Pp,Pa,Xvel,6,Cps,Cpt)
381 !CALCULATE THE QUANTITIES TO BE MASS AVERAGED. MULTIPLY THESE VALUES
382 !BY Kn TO GET THE INTEGRAND REQUIRED TO CALCULATE THE MASS AVERAGED CP'S
383 CALL Cpintegrand(Pp,Pl,Pa,6,Xvel,A,8,Kn)
384 !CALCULATE Pp-Pl/Qref FOR PLOTS
385 CALL Prefqref(Pp,Pl,Qref,Pq)

```

```

386  I CALCULATE STATIC PRESSURE UPSTREAM
387  CALL Staticpress(P1,Pa,Xvel,6,Ps)
389  IDEFINE AN ARRAY TO STORE CALCULATED VALUES
390  Calc1(N,1)=Posit
391  Calc1(N,2)=Beta
392  Calc1(N,3)=Gamma
393  Calc1(N,4)=Phi
394  Calc1(N,5)=Xvel
395  Calc1(N,6)=Xref
396  Calc1(N,7)=Vel
397  Calc1(N,8)=Mach
398  Calc1(N,9)=Yaw
399  Calc1(N,10)=Kn
400  Calc1(N,11)=Cpt
401  Calc1(N,12)=Cps
402  Calc1(N,13)=Qref
403  Calc1(N,14)=Uref
404  Calc1(N,15)=Q
405  Calc1(N,16)=A
406  Calc1(N,17)=B
407  Calc1(N,18)=Pq
408  Calc1(N,19)=Pa
409
411  Calc1(N,20)=Ps
412  Knaray(N)=Calc1(N,10)
413
414
415  Prbpos(N)=Calc1(N,1)
416  Aaray(N)=Calc1(N,16)
417  Baray(N)=Calc1(N,17)
418  Scan=N
419  NEXT N
420 Twoprintcalc1: OFF END @Path1
421  I CALCULATE ENSEMBLE AVERAGE OF XREF
422  CALL Xrefensemble(Pavg,Ppavg,6,Xrefavg)
423  I CALCULATE ENSEMBLE AVERAGE OF UREF
424  CALL Urefensemble(Xrefavg,Cp,Tempavg,Urefavg)
425  I CALCULATE ENSEMBLE AVERAGE OF QREF
426  CALL Qrefensemble(Pavg,Ppavg,6,Xrefavg,Qrefavg)
427  PRINT "....."
428  PRINT ""
429  PRINT "ALIGN PAPER IN PRINTER. WHEN READY FOR A HARDCOPY OF THE "
430  PRINT "CALCULATED DATA, PRESS ""REDUCED DATA""."
431  PRINT ""
432  PRINT "....."
433  ON KEY 1 LABEL "REDUCED DATA" GOTO Prntdata2
434 Spin2: GOTO Spin2
435 Prntdata2: PRINTER IS Prnter
436  PRINT "....."
437  PRINT "FILE ",Calc1file$
438  PRINT "....."
439  PRINT "....."
440  PRINT ""
441  PRINT "SCAN  L PRB      BETA      GAMMA      PHI      Xvel
Xref "
442  PRINT "      POSIT"
443  FOR N=1 TO Scan
444  PRINT USING "4D,3X,4D.2D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3DE
":N,Calc1(N,1),Calc1(N,2),Calc1(N,3),Calc1(N,4),Calc1(N,5),Calc1(N,6)
445  NEXT N
446  PRINT ""
447  PRINT "....."
448  PRINT ""
449  PRINT "SCAN  VEL      UREF      Q      QREF      MACH

```

IFa & Ps ARE USED FOR STATIC PRESS
 IRISE CALCULATION IN PROGRAM LOSS.
 ITHESE VALUES ARE NOT PRINTED.
 IWANT TO STORE MORE THAN JUST ONE
 IKn VALUE FOR MASS AVERAGING
 I CALCULATIONS.
 I"" ""
 I"" ""
 I"" ""

```

      YAW"
450 PRINT "
      DEG "
451 FOR N=1 TO Scan
452 PRINT USING "4D,3X,M0.30E,3X,M0.30E,3X,M0.30E,3X,M0.30E,2X,M0.30E,2X,M0.30
E"iN,Calcl(N,7),Calcl(N,14),Calcl(N,15),Calcl(N,13),Calcl(N,8),Calcl(N,9)
453 NEXT N
454 PRINT ""
455 PRINT "....."
456 PRINT ""
457 PRINT "....."
458 PRINT ""
459 PRINT "SCAN Pref-Ptl/Qref"
460 FOR N=1 TO Scan
461 PRINT USING "4D,3X,M0.30E"iN,Calcl(N,18)
462 NEXT N
463 PRINT ""
464 PRINT "....."
465 PRINT ""
466 PRINT "ENSEMBLE AVERAGES"
467 PRINT ""
468 PRINT "PPAVG          PAAVG          TEMPAVG          XREFAVG          VREFAVG
QREFAVG "
469 PRINT USING "M0.30E,5X,M30.20E,5X,3D,2D,5X,M0.30E,5X,M0.30E,3X,M0.30E"iPpa
vg,Pavg,Tempavg,Xrefavg,Vrefavg,Qrefavg
470 OUTPUT @Path4;Calcl(*)
471 DIM Calcu(100,25)
472
473 MAT Calcu= (0)
474 FOR N=1 TO 100
475 ENTER @Path1,N;Reddat(*)
476 DN END @Path1 6D TO Twoprntcalc2
477 Ptare=Reddat(1,1)
478 Pp=Reddat(1,3)
479 Ps=Reddat(1,4)
480 Ptp=Reddat(1,10)
481 Psp=Reddat(1,11)
482 Plu=Reddat(1,13)
483 P2u=Reddat(1,14)
484 P3u=Reddat(1,15)
485 P2u3u=(P2u+P3u)/2
486 P4u=Reddat(1,16)
487 P5u=Reddat(1,17)
488 IBLANK=REODAT(1,18)
489 IBLANK=REODAT(1,19)
490 Positu=Reddat(1,21)
491 Yawu=Reddat(1,23)
492 Temp=Reddat(1,24)
493 Pa=Reddat(1,25)
494 I CALCULATE BETA AND GAMMA COEFFICIENTS
495 CALL Bgcalc(Pa,Plu,P2u3u,P4u,P5u,8etau,Gammau)
496 I CALCULATE Xvelu AND Phiu
497 CALL Xphicalc(8etau,Gammau,Xvelu,Xu(*),Phiu,Pu(*))
498 I CALCULATE Xrefu
499 CALL Xrefcalc(Pa,Pp,G,Xrefu)
500 I CALCULATE QREF AND VREF
501 CALL Qvrefcalc(Xref,Cp,Temp,G,Pp,Pa,Qref,Vref)
502 I CALCULATE VELOCITYu AND MACHu # AND Qu
503 CALL Vmqcalc(Xvelu,Cp,Temp,G,Velu,Machu,Plu,Pa,Qu)
504 I CALCULATE THE INTEGRAND FOR THE AVOR EXPRESSION
505 CALL Kncalc(Pa,Plu,Pp,Xvelu,Xrefu,G,Yawu,Knu)
506 I CALCULATE THE COEFFICIENT OF PRESSURE FOR THE UPPER PROBE.
507 I THIS TERM WILL BE MASS AVERAGED AND USED IN THE CALCULATION OF THE

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508 ! LOSS COEFFICIENT. THE Cpsu TERM IS NOT USED IN THE LOSS COEFFICIENT
509 ! CALCULATION.
510 CALL Coefpress(Piu,Pp,Pa,Xvelu,G,Cpsu,Cptu) _
511 ! CALCULATE Pp-P1/Qref FOR PLOTS
512 CALL Prefqref(Pp,P1,Qref,Pqu)
513 ! CALCULATE THE DOWNSTREAM STATIC PRESSURE
514 CALL Staticpress(Piu,Pa,Xvelu,G,Psu)
515 Calcu(N,1)=Positu
516 Calcu(N,2)=Betau
517 Calcu(N,3)=Gammau
518 Calcu(N,4)=Phiu
519 Calcu(N,5)=Xvelu
520 Calcu(N,6)=Xrefu
521 Calcu(N,7)=Velu
522 Calcu(N,8)=Mach
523 Calcu(N,9)=Yawu
524 Calcu(N,10)=Knu
525 Calcu(N,11)=Cptu
526 Calcu(N,12)=Cpsu
527 Calcu(N,13)=Qu
528 Calcu(N,14)=Pqu
529 Calcu(N,15)=Pa
530 Calcu(N,16)=Psu
531 Calcu(N,17)=Pa
532 Calcu(N,18)=Psu
533 Calcu(N,19)=Pa
534 Calcu(N,20)=Psu
535 Scan=N
536 NEXT N
537 Twoprintcalc2: OFF END @Path1
538 PRINT "....."
539 PRINT ""
540 PRINT "....."
541 PRINT "FILE ",Calcufile$
542 PRINT "....."
543 PRINT "....."
544 PRINT ""
545 PRINT "SCAN U PRB BETAU GAMMAU PHIU Xvelu "
546 PRINT " POSIT"
547 FOR N=1 TO Scan
548 PRINT USING "4D,2X,4D,2D,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE" IN,Calcu(
N,1),Calcu(N,2),Calcu(N,3),Calcu(N,4),Calcu(N,5)
549 NEXT N
550 PRINT "....."
551 PRINT ""
552 PRINT "SCAN VELU QU Pref-Ptu/Qref MACHU YAWU"
553 PRINT " DEG"
554 FOR N=1 TO Scan
555 PRINT USING "4D,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE,3X,MD,3DE" IN,Calcu
(N,7),Calcu(N,13),Calcu(N,14),Calcu(N,8),Calcu(N,9)
556 NEXT N
557 PRINT "....."
558 PRINTER IS Screen
559 OUTPUT @Path5;Calcu(*)
560 ELSE
561 MASS STORAGE IS "/CLASSICK/REDDATA"
562 PRINT "....."
563 PRINT ""
564 PRINT "ENTER THE FILENAME FOR THE DATA TO BE CALCULATED FROM THE PROBE "
565 INPUT Calcfile$
566 CREATE BDAT Calcfile$,100
567 ASSIGN @Path4 TO Calcfile$
568 !.....

```

```

569 |..... ONE PROBE .....
570 |.....SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENT.....
571 |.....
572 |.....
573 |* VARIABLE VARIABLE PORT/CHANNEL DATA ARRAY
574 |* REPRESENTS
575 |*
576 |* Ptare Pa-Pa PORT 1 Reddat(1,1)
577 |* Pcal Pcal-Ptare PORT 2 Reddat(1,2)
578 |* Pp Pplenum-Ptare PORT 3 Reddat(1,3)
579 |* Ps Pwallstatic-Ptare PORT 4 Reddat(1,4)
580 |* P1 P1-Ptare PORT 5 Reddat(1,5)
581 |* P2 P2-Ptare PORT 6 Reddat(1,6)
582 |* P3 P3-Ptare PORT 7 Reddat(1,7)
583 |* P23 (P2+P3)/2
584 |* P4 P4-Ptare PORT 8 Reddat(1,8)
585 |* P5 P5-Ptare PORT 9 Reddat(1,9)
586 |* Ptp Ptotalprndtl-Ptare PORT 10 Reddat(1,10)
587 |* Psp Pstatprndtl-Ptare PORT 11 Reddat(1,11)
588 |* BLANK PORT 12 Reddat(1,12)
589 |* BLANK PORT 13 Reddat(1,13)
590 |* BLANK PORT 14 Reddat(1,14)
591 |* Posit PR8 POSIT INPUT Reddat(1,15)
592 |* Yaw PR8 YAW CHAN 24 Reddat(1,16)
593 |* Temp TOTAL TEMP(PLENUM) CHAN 10 Reddat(1,17)
594 |* Pa ATMOSPHERIC PRESS INPUT Reddat(1,18)
595 |*
596 |*
597 |.....
598 |.....DATA REDUCTION.....
599 OIM Calc(100,25)
600 MAT Calc=(0)
601 Pinitial=0 INITIALIZES CONDITIONS FOR ENSEMBLE
602 CALCULATIONS IN SUBROUTINE ENSEMBLE.
603 Tinitial=0
604 Pinitial=0
605 FOR N=1 TO 100
606 ENTER @Path1,N,Reddat(*) IARRAY ENTERED RANDOMLY
607 ON END @Path1 GOTO Printcalc1
608 Ptare=Reddat(1,1) REASSIGNMENT OF ARRAY ELEMENTS TO
609 IDENTIFIABLE QUANTITIES USED IN
610 SUBROUTINE CALCULATIONS.
611 Pcal=Reddat(1,2)
612 Pp=Reddat(1,3)
613 Ps=Reddat(1,4)
614 P1=Reddat(1,5)
615 P2=Reddat(1,6)
616 P3=Reddat(1,7)
617 P23=(P2+P3)/2
618 P4=Reddat(1,8)
619 P5=Reddat(1,9)
620 Ptp=Reddat(1,10)
621 Psp=Reddat(1,11)
622 IBLANK=Reddat(1,12)
623 IBLANK=Reddat(1,13)
624 IBLANK=Reddat(1,14)
625 Posit=Reddat(1,15)
626 Yaw=Reddat(1,16)
627 Temp=Reddat(1,17)
628 Pa=Reddat(1,18)
629 ICALCULATE BETA AND GAMMA COEFFICIENTS
630 CALL Bgcalc(Pa,P1,P23,P4,P5,Beta,Gamma)
631 ICALCULATE THE ENSEMBLE REFERENCE VALUES OF PPLENUM,PLENUM TEMP AND PA.
632 CALL Ensemble(Pp,Pinitial,Pa,Pinitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
633 ICALCULATE Xvel AND Phi
634 CALL Xphicalc(Beta,Gamma,Xvel,X(*),Phi,P(*))

```

```

635 I CALCULATE Xref
636 CALL Xrefcalc(Pa,Pp,G,Xref)
637 I CALCULATE QREF AND UREF
638 CALL Qvrefcalc(Xref,Cp,Temp,G,Pp,Pa,Qref,Uref)
639 I CALCULATE VELOCITY AND MACH # AND Q
640 CALL Vmcalc(Xvel,Cp,Temp,G,Uel,Mach,P1,Pa,Q)
641 I CALCULATE THE INTEGRAND FOR THE AVOR EXPRESSION
642 CALL Kncalc(Pa,P1,Pp,Xvel,Xref,G,Yaw,Kn)
643 I CALCULATE THE COEFFICIENT OF PRESSURE TERMS TO BE MASS AVERAGED.
644 I THESE TERMS ARE USED IN THE CALCULATION OF THE LOSS COEFFICIENT.
645 CALL Coefpress(P1,Pp,Pa,Xvel,G,Cps,Cpt)
646 I CALCULATE THE QUANTITIES TO BE MASS AVERAGED. MULTIPLY THESE VALUES
647 BY Kn TO GET THE INTEGRAND REQUIRED TO CALCULATE THE MASS AVERAGED CP'S
648 CALL Cpintegrand(Pp,P1,Pa,G,Xvel,A,B,Kn)
649 I CALCULATE Pp-P1/Qref FOR PLOTS
650 CALL Prefqref(Pp,P1,Qref,Pq)
651 I CALCULATE STATIC PRESSURE
652 CALL Staticpress(P1,Pa,Xvel,G,Ps)
653 I DEFINE AN ARRAY TO STORE CALCULATED VALUES
654 Calc(N,1)=Posit
655 Calc(N,2)=Beta
656 Calc(N,3)=Gamma
657 Calc(N,4)=Phi
658 Calc(N,5)=Xvel
659 Calc(N,6)=Xref
660 Calc(N,7)=Uel
661 Calc(N,8)=Mach
662 Calc(N,9)=Yaw
663 Calc(N,10)=Kn
664 Calc(N,11)=Cpt
665 Calc(N,12)=Cps
666 Calc(N,13)=Qref
667 Calc(N,14)=Uref
668 Calc(N,15)=Q
669 Calc(N,16)=A
670 Calc(N,17)=B
671 Calc(N,18)=Pq
672 Calc(N,19)=Pa
673 Calc(N,20)=Ps
674 Kncaray(N)=Calc(N,10)          IWANT TO STORE THE Kn VALUE IN AN
675                                IARRAY FOR MASS AVERAGING CALCULATIONS
676 Prbpos(N)=Calc(N,1)           I"" ""
677 Aaray(N)=Calc(N,16)           I"" ""
678 Baray(N)=Calc(N,17)           I"" ""
679 Scan=N
680 NEXT N
681 Printcalcl: OFF END @Path1
682 I CALCULATE ENSEMBLE AVERAGE OF XREF
683 CALL Xrefensemble(Paavg,Ppavg,G,Xrefavg)
684 I CALCULATE ENSEMBLE AVERAGE OF UREF
685 CALL Urefensemble(Xrefavg,Cp,Tempavg,Urefavg)
686 I CALCULATE ENSEMBLE AVERAGE OF QREF
687 CALL Qrefensemble(Paavg,Ppavg,G,Xrefavg,Qrefavg)
688 PRINT "....."
689 PRINT ""
690 PRINT "ALIGN PAPER IN THE PRINTER. WHEN READY FOR A HAROCOPY OF THE "
691 PRINT ""
692 PRINT "CALCULATED DATA, PRESS ""REDUCED DATA"" ."
693 PRINT ""
694 PRINT "....."
695 ON KEY 4 LABEL "REDUCED DATA" GOTO Prntdata1
696 Spin3: GOTO Spin3
697 Prntdata1: PRINTER IS Prnter
698 PRINT "....."
699 PRINT "FILE ",Calcfile$
700 PRINT "....."

```

```

701 PRINT ""
702 PRINT "....."
703 PRINT ""
704 PRINT "SCAN   PRB       BETA       GAMMA       PHI       XveI
      Xref"
705 PRINT "      PDSIT"
706 FOR N=1 TO Scan
707 PRINT USING "4D,3X,40.20,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE
      "iN,CaIc(N,1),CaIc(N,2),CaIc(N,3),CaIc(N,4),CaIc(N,5),CaIc(N,6)
708 NEXT N
709 PRINT ""
710 PRINT "....."
711 PRINT ""
712 PRINT "SCAN   VeI       Uref       Q       Qref       MACH
      YAW"
713 PRINT "
      OEG"
714 FOR N=1 TO Scan
715 PRINT USING "4D,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,3X,MD.3DE,2X,MD.3DE,2X,MD.3D
      E"iN,CaIc(N,7),CaIc(N,14),CaIc(N,15),CaIc(N,13),CaIc(N,8),CaIc(N,9)
716 NEXT N
717 PRINT ""
718 PRINT "....."
719 PRINT ""
720 PRINT "SCAN   Pref-Pt/Qref"
721 FOR N=1 TO Scan
722 PRINT USING "4D,3X,MD.3DE"iN,CaIc(N,18)
723 NEXT N
724 PRINT ""
725 PRINT "....."
726 PRINT ""
727 PRINT "ENSEMBLE AVERAGES"
728 PRINT ""
729 PRINT "PPAVG       PAAVG       TEMPAVG       XREFAVG       UREFAVG
      QREFAVG"
730 PRINT USING "MD.3DE,5X,M30.2DE,5X,30.20,5X,MD.3DE,5X,MD.3DE,3X,MD.3DE"iPpa
      vg,Paavg,Temavg,Xrefavg,Urefavg,Qrefavg
731 PRINTER IS Screen
732 OUTPUT @Path4;Calc(*)          SERIAL OUTPUT STATEMENT.
733 END IF
734 PRINT "....."
735 PRINT ""
736 PRINT "TO CALCULATE THE CP'S FOR THE BLADE DATA, PRESS ""BLADE CP'S""
737 PRINT "PRESS ""GO DN"" TO CONTINUE."
738 PRINT ""
739 PRINT "....."
740 DN KEY 1 LABEL "BLADE   CP'S" 6DTD CaIcUlatecp
741 ON KEY 4 LABEL "GO ON" 60TD Loadoption2
742 Spin4: 6DTD Spin4
743 CaIcUlatecp: MASS STORAGE IS "/CLASSICK/REDOATA"
744 PRINT ""
745 PRINT "....."
746 PRINT ""
747 PRINT "ENTER THE FILE NAME OF THE BLADE DATA SCALED IN ENGINEERING UNITS"
748 INPUT ScIbladfile$
749 PRINT "....."
750 ASSIGN @Path5 TO ScIbladfile$
751 PRINT ""
752 PRINT "ENTER THE FILE NAME TO STORE THE MASS AVERAGED CP'S CALCULATED"
753 PRINT "FROM THE BLADE DATA."
754 INPUT Bladcalc$

```

```

755 CREATE BOAT Bladcalc$,100
756 ASSIGN @Path6 TO Bladcalc$
757 DIM Prntdata(1,48)          !DIMENSION STATEMENTS FOR BLADE ARRAYS
758                               !ARE HERE SO ARRAY SPACE IS ONLY ASSIGNED
759                               !IF BLADE OPTION IS SELECTED.
760 DIM Cpmassavg(48)
761 MAT Cpmassavg= (0)
762 MAT Prntdata= (0)
763 PRINT "....."
764 PRINT ""
765 PRINT "ENTER THE LIMITS OF INTEGRATION i.e., THE LOWEST TO THE "
766 PRINT "HIGHEST SCAN NUMBER DESIRED."
767 PRINT ""
768 PRINT "....."
769 PRINT ""
770 PRINT "....."
771 PRINT ""
772 PRINT "ENTER THE LOW SCAN"
773 INPUT Lowpoint
774 PRINT "....."
775 PRINT ""
776 PRINT "ENTER THE HIGH SCAN"
777 INPUT Hipoint
778 LOADSUB ALL FROM "/CLASSICK/ROUTINES/LOSSCALC"
779 !INTEGRATE A
780 CALL Datint(Lowpoint,Hipoint,Aarray(*),Prbpos(*),Aintg)
781 !INTEGRATE B
782 CALL Datint(Lowpoint,Hipoint,Barray(*),Prbpos(*),Bintg)
783 !INTEGRATE Kn
784 CALL Datint(Lowpoint,Hipoint,Knarray(*),Prbpos(*),Knintg)
785 A1=Aintg/Knintg
786 B1=Bintg/Knintg
787 ENTER @Path5;Prntdata(*)
788 Pp=Prntdata(1,3)
789 FOR N=Firstbladeprt TO Lastbladeprt !OBTAINED FROM PORT ASSIGNMENT SHEET
790 PlocaI=Prntdata(1,N)
791 CALL CpcaIc(A1,B1,Pp,PlocaI,C)
792 Cpmassavg(N)=C
793 NEXT N
794 PRINT "....."
795 PRINT ""
796 PRINT "ALIGN PAPER IN PRINTER AND PRESS ""BLADE DATA"" FOR HARD COPY"
797 PRINT " OF BLADE MASS AVERAGED COEFFICIENTS OF PRESSURE."
798 PRINT ""
799 PRINT "....."
800 ON KEY 1 LABEL "BLADE DATA" GOTO Prntbladeprdata
801 Spin5: GOTO Spin5
802 Prntbladeprdata: PRINTER IS Prnter
803 PRINT "....."
804 PRINT "BLADE CP FILE ",Bladcalc$
805 PRINT "....."
806 PRINT ""
807 PRINT "SCANIVALVE          MASS AVERAGED COEFFICIENT"
808 PRINT "PORT              OF PRESSURE          "
809 FOR N=Firstbladeprt TO Lastbladeprt
810 PRINT USING "20,15X,MD.3DE" IN,Cpmassavg(N)
811 NEXT N
812 OUTPUT @Path5;Cpmassavg(*)          !SERIAL OUTPUT STATEMENT
813 Loadoption2: PRINTER IS Screen
814 PRINT "....."
815 PRINT ""
816 PRINT "TO LOAD PROGRAM THAT CALCULATES THE AVOR AND LOSS COEFFICIENT,"
817 PRINT ""
818 PRINT "PRESS ""LOSS"", PRESS ""GO ON"" TO TERMINATE THE PROGRAM."
819 PRINT ""

```

```

820 PRINT "....."
821 ON KEY 1 LABEL "LOSS" GOTO Loadup2
822 ON KEY 4 LABEL "GO ON" GOTO Fin
823 Spin6: GOTO Spin6
824 Loadup2: MASS STORAGE IS "/CLASSICK/PROGS"
825 LOAD "LOSS",10
826 Fin: PRINT ""
827 PRINT "....."
828 PRINT ""
829 PRINT "                END OF PROGRAM"
830 PRINT ""
831 PRINT "....."
832 END

```

B7.3 Reduction Program LOSS

```

10  IPROGRAM LOSS
20  ITHIS PROGRAM USES VALUES FROM THE CALC ARRAYS GENERATED BY REDUCING
30  ISCALED DATA IN PROGRAM CALC. SUBROUTINES INTEGRATE THESE VALUES AND A
50  ISTATIC FRESSURE RISE COEFFICIENT,AVOR & LOSS COEFFICIENT IS CALCULATED.
51  IMUCH OF THE CODING WAS PREVIOUSLY COMMENTED ON IN PROGRAM ACQUIRE AND
52  IPROGRAM CALC.
60  IOPTION BASE 1
70  DIM Calc1(100,25)          INOTE THAT u AND I DESIGNATORS DISTINGUISH
71                               ITHOSE VALUES FROM UPPER SURVEY AND LOWER
72                               ISURVEY STATIONS RESPECTIVELY.
80  DIM Calcu(100,25)
90  DIM Posit(100)
100 DIM Positu(100)
110 DIM Kn(100)                ISEE TABLE I OF CLASSICK THESIS Kn=K.
120 DIM Knu(100)
121 DIM Cpt(100)               ITHese VALUES PREVIOUSLY DEFINED IN "CALC"
122 DIM Cptu(100)
123 DIM Cps(100)
124 DIM Y(100)                 IAN INTERMEDIATE QUANTITY IN THE STATIC
125                               IFRESSURE RISE COEFFICIENT CALCULATION.
129 DIM Z(100)                I-
131 DIM Cptxkn(100)           ICOMBINED VALUES TO MAKE THE INTEGRATIONS
132 DIM Cptuxknu(100)         IMORE EXPLICIT TO THE PROGRAMMER.
133 DIM Cpsxkn(100)
134 DIM Yxkn(100)
135 DIM Zxknu(100)
136 MAT Calc1= (0)
137 MAT Calcu= (0)
138 MAT Posit= (0)
139 MAT Positu= (0)
140 MAT Kn= (0)
141 MAT Knu= (0)
142 MAT Cpt= (0)
143 MAT Cptu= (0)
144 MAT Cps= (0)
145 MAT Cptxkn= (0)
146 MAT Cptuxknu= (0)
147 MAT Cpsxkn= (0)
148 MAT Yxkn= (0)
149 MAT Zxknu= (0)
150 LOADSUB ALL FROM "/CLASSICK/ROUTINES/LOSSCALC"
151 MASS STORAGE IS "/CLASSICK/REDDATA"
152 PRINT "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE"
153 PRINT "LOWER PROBE"
154 PRINT "....."
155 INPUT Calc1file$
156 ASSIGN @Path1 TO Calc1file$
157 ENTER @Path1|Calc1(0)
158 FOR N=1 TO 100
159   Posit(N)=Calc1(N,1)
212  Kn(N)=Calc1(N,10)
213  Cpt(N)=Calc1(N,11)
214  Cps(N)=Calc1(N,12)
215  Pal=Calc1(N,19)
216  Psl=Calc1(N,20)
217  Q1=Calc1(N,15)
218  IF Q1=0 THEN Skipy          IPREVENTS A DIVISION BY ZERO IF THE
219                               IARRAY IS NOT ENTIRELY FILLED WITH
220                               INONZERO VALUES I.e., TOTAL DATA POINTS
221                               ITAKEN DID NOT EQUAL 100.
222  Y(N)=(Pal-Psl)/Q1
224  Cptxkn(N)=Cpt(N)*Kn(N)
225  Cpsxkn(N)=Cps(N)*Kn(N)
226  Yxkn(N)=Y(N)*Kn(N)
227  NEXT N

```

```

231 Skipz: PRINT "ENTER THE NAME OF THE FILE CONTAINING THE CALCULATED DATA FROM THE"
232 PRINT "UPPER PROBE"
233 PRINT "....."
234 INPUT Calcufile$
235 ASSIGN @Path2 TO Calcufile$
236 ENTER @Path2;Calcu(*)
237 FOR N=1 TO 100
238 Positu(N)=Calcu(N,1)
239 Knu(N)=Calcu(N,10)
240 Cptu(N)=Calcu(N,11)
241 Pau=Calcu(N,19)
242 Pau=Calcu(N,20)
243 Ou=Calcu(N,15)
244 IF Ou=0 THEN Skipz
245 Z(N)=(Pau-Pau)/Ou
246 Cptuxknu(N)=Cptu(N)*Knu(N)
247 Zxknu(N)=Z(N)*Knu(N)
248 NEXT N
249 Skipz: PRINT ""
250 PRINT "ENTER THE LIMITS OF INTEGRATION FOR THE LOWER PROBE SURVEY"
251 PRINT ""
252 PRINT "....."
253 INPUT "ENTER THE FIRST POINT",Lowpoint
254 INPUT "ENTER THE LAST POINT",Hipoint
255 I CALL THE INTEGRATION ROUTINE
256 CALL Datint(Lowpoint,Hipoint,Kn(*),Posit(*),Denominator)
257 CALL Datint(Lowpoint,Hipoint,Cptxkn(*),Posit(*),Intega)
258 CALL Datint(Lowpoint,Hipoint,Cpsxkn(*),Posit(*),Integc)
259 CALL Datint(Lowpoint,Hipoint,Yxkn(*),Posit(*),Integy)
263 PRINT ""
264 PRINT "ENTER THE LIMITS OF INTEGRATION FOR THE UPPER PROBE SURVEY"
265 PRINT ""
266 PRINT "....."
267 INPUT "ENTER THE FIRST POINT",Lowpoint
268 INPUT "ENTER THE LAST POINT",Hipoint
269 CALL Datint(Lowpoint,Hipoint,Knu(*),Positu(*),Numerator)
270 CALL Datint(Lowpoint,Hipoint,Cptuxknu(*),Positu(*),Integb)
271 CALL Datint(Lowpoint,Hipoint,Zxknu(*),Positu(*),Integz)
272 Cp2=(Integz/Denominator)+(Integy/Denominator)
273 Avdr=Numerator/Denominator
274 PRINT "STATIC PRESSURE RISE COEFFICIENT"
275 PRINT USING "MD.3DE";Cp2
276 PRINT ""
277 PRINT "AVDR"
278 PRINT USING "MD.3DE";Avdr
279 PRINT ""
280 W=(Intega-(1/Avdr)*(Integb))/(Intega-Integc)
281 PRINT "LOSS COEFFICIENT"
282 PRINT USING "MD.3DE";W
283 PRINT "....."
284 PRINT ""
285 PRINT "
286 PRINT ""
287 PRINT "....."
288 END

```

B7.4 Subprogram SUBACQUIRE

```

1   IFILE SUBACQUIRE
10  ITHIS FILE CONTAINS THE SUBPROGRAMS FOR POSITIONING THE SCANIVALVE
20  IPORTS AND READING THE OVM.
720 SUB Scnvpportposit(Scnv,Op,Scnhmsvc,Scnstpsvc) ITHE STRUCTURE OF THIS
721 ISUBPROGRAM IS SIMILAR TO PREVIOUS
722 IACQUISITION PROGRAMS WRITTEN AT THE
723 ITPL. SEE GEOPFARTH THESIS.
725   OPTION BASE I
726   COM /Positvrbis/ Svc,Scn
727 Posit:OUTPUT Svc USING "S,K":Scnv
728   Z=SPOLL(Svc)
729   U=BINAND(Z,15)
730   V=SHIF1(Z,4)
731   T=BINAND(V,7)
732   P=10+T+U
733
735   CLEAR Svc
736   IF P=Op THEN Retrn
737   IF P>Op THEN
738     OUTPUT Scn USING "Z":Scnhmsvc IHOME THE SCANIVALVE
739     CLEAR Scn
740     WAIT 4
741     IALLOW 4 SECONDS FOR THE HOME TO
742     ICOMPLETE.
743     GOTO Posit
744   ELSE
745     OUTPUT Scn USING "Z":Scnstpsvc ISTEP THE SCANIVALVE
746     CLEAR Scn
747     WAIT .1
748     IWAIT 1/10 SEC BETWEEN STEPS
749     GOTO Posit
750   END IF
750 Retrn: SUBEND
751 SUB Readdvm(Op,ChanIassign)
752   OPTION BASE I
753   COM /Positvrbis/ Svc,Scn
754   COM /Readvrbis/ Scan,Ovm,Scanvb(1,48),Tempchnrd,Yawchnrd,Scnyawchn,Scnte
mpchn,Scnrdsvcb,Scanva(1,48),Scnrdsvca,Noofprbs,Yawchnrdu,Scnrdsvc
755   COM /Readvrbis/ Yawchnrd1,Scnyawchnu,Scnyawchn1,Maxdif
756   OUTPUT Scn USING "Z":ChanIassign ICHANLASIGN TAKES ON THE VALUE
757   IASSIGNED TO IT BY THE CALLING
758   ISTATEMENT IN THE MAIN PROGRAM.
759   OUTPUT Ovm:Fir7m3a0h013
760   ISTANDARD SETTING FOR THE OVM.
761   ISETS THE FUNCTIONS ON THE PANEL.
763 Sample: DIM A(5)
764   MAT A= (0)
765   FOR I=1 TO 5
766     ITAKE 5 READINGS AND STORE IN THE
767     I"A" ARRAY
768   TRIGGER Ovm
769     ENTER Ovm:A(I)
770     Avg=SUM(A)/I
771     Dev=A(I)-Avg
772     I(AVERAGE THE 5 READINGS
773     IERROR TRAP FOR SPURIOUS OVM READINGS
774     PRINT "SAMPLE EXCEEDED MAXIMUM DEVIATION ALLOWED-SAMPLE RETAKEN"
775     GOTO Sample
776   END IF
777   NEXT I
778   IF Noofprbs=1 THEN Readone
779   IF ChanIassign=Scnrdsvcb THEN
780     Scanvb(1,Op)=SUM(A)/5
781   ELSE
782     IF ChanIassign=Scnyawchn1 THEN
783       Yawchnrd1=SUM(A)/5
784     ELSE
785       IF ChanIassign=Scnyawchnu THEN
786         Yawchnrdu=SUM(A)/5

```

```

787         ELSE
788             GOTO Tempread
789         END IF
790     END IF
791 END IF
792 Readone: IF Chanlsgn=Scnrdsve THEN
793     Scanvb(1,Op)=SUM(A)/5
794 ELSE
795     IF Chanlsgn=Scnyawchn THEN
796         Yawchnrd=SUM(A)/5
797     ELSE
798         Tempread: Tempchnrd=SUM(A)/5
799     END IF
800 END IF
801 IF Chanlsgn=Scnrdsve THEN Scanvb(1,Op)=SUM(A)/5
802 Retrn: CLEAR Scn
803 SUBEND

```

B7.5 Subprogram SUBCALC

```

1      IFILE SUBCALC
10     ITHIS FILE CONTAINS ALL THE CALCULATION SUBROUTINES CALLED BY THE
20     IDATA REDUCTION PROGRAM CALC.
798    SUB Bpcalc(Pa,P1,P23,P4,P5,Beta,Gamma)
799    Beta=(P1-P23)/(P1+Pa)
800    Gamma=(P4-P5)/(P1-P23)
801    SUBEND
802    SUB Xphicalc(Beta,Gamma,Xvel,X( ),Phi,P( ))
803    OPTION BASE 1
804    DIM E(6)
805    DIM F(6)
806    MAT E= (0)
807    MAT F= (0)
808    FOR J=1 TO 6
809    E(J)=X(1,J)+X(2,J)*Gamma+X(3,J)*Gamma^2+X(4,J)*Gamma^3+X(5,J)*Gamma^4+X(6,
J)*Gamma^5
810    F(J)=P(1,J)+P(2,J)*Gamma+P(3,J)*Gamma^2+P(4,J)*Gamma^3+P(5,J)*Gamma^4+P(6,
J)*Gamma^5
811    NEXT J
812    Xvel=E(1)+E(2)*Beta+E(3)*Beta^2+E(4)*Beta^3+E(5)*Beta^4+E(6)*Beta^5
813    Phi=F(1)+F(2)*Beta+F(3)*Beta^2+F(4)*Beta^3+F(5)*Beta^4+F(6)*Beta^5
814    SUBEND
815    SUB Vnqcalc(Xvel,Cp,Temp,G,Val,Mach,P1,Pa,Q)
816    Vel=Xvel*(2*Cp*778*32.174*Temp)^.5
817    Mach=((Xvel^2)/(1-Xvel^2))*(2/(6-1)))^.5
818    Q=(P1+Pa)*(6/(6-1))*Xvel^2*((1-Xvel^2)^(1/(6-1)))
819    SUBEND
820    SUB Xrefcalc(Pa,Pp,G,Xref)
821    Xref=(1-(Pa/(Pp+Pa))^(6-1)/6))^.5
822    SUBEND
823    SUB Kncalc(Pa,P1,Pp,Xvel,Xref,G,Yaw,Kn)
824    Kn=((P1+Pa)/(Pp+Pa))*(Xvel/Xref)*(((1-Xvel^2)/(1-Xref^2))^(1/(6-1)))
* COS(Yaw)
825    SUBEND
826    SUB Coefpress(P1,Pp,Pa,Xvel,G,Cps,Cpt)
827    Cpt=(P1+Pa)/(Pp+Pa)
828    Cps=((P1+Pa)*(((1-Xvel^2)^(6/(6-1))))/(Pp+Pa)
829    SUBEND
836    SUB Ensemble(Pp,Pinitial,Pa,Painitial,Temp,Tinitial,Ppavg,Paavg,Tempavg,N)
837    Ppe=Pp+Pinitial
838    Ppavg=Ppe/N
839    Pinitial=Ppe
840    Te=Temp+Tinitial
841    Tempavg=Te/N
842    Tinitial=Te
843    Pae=Pa+Painitial
844    Paavg=Pae/N
845    Painitial=Pae
846    SUBEND

```

```

867 SUB Xrefensenble(Paavg,Ppavg,6,Xrefavg)
868 Xrefavg=(1-((Paavg)/(Ppavg+Paavg))^(6-1)/6))^.5
869 SUBEND
870 SUB Urafensenble(Xrefavg,Cp,Tempavg,Urafavg)
871 Urafavg=Xrefavg*(2*Cp*Tempavg+778*32.174)^.5
872 SUBEND
873 SUB Qrafensenble(Paavg,Ppavg,6,Xrefavg,Qrafavg)
874 Qrafavg=(Ppavg+Paavg)*(6/(6-1))*Xrefavg^2*(1-Xrefavg^2)^(1/(6-1))
875 SUBEND
876 SUB Qvrefcalc(Xref,Cp,Temp,6,Pp,Pa,Qraf,Uref)
877 Uref=Xref*(2*Cp+778*32.174*Temp)^.5
878 Qraf=(Pa+Pp)*(6/(6-1))*(Xref^2)*((1-Xref^2)^(1/(6-1)))
879 SUBEND
880 SUB Cpintegrant(Pp,P1,Pa,6,Xvel,A,B,Kn)
881 M=Pp/(((P1+Pa)*(6/(6-1))*Xvel^2*((1-Xvel^2)^(1/(6-1))))))
882 N1=(Pa/(P1+Pa))-((1-Xvel^2)^(6/(6-1)))
883 N2=(6/(6-1))*Xvel^2*((1-Xvel^2)^(1/(6-1)))
884 N=N1/N2
885 A=M*Kn
886 B=N*Kn
887 SUBEND
888 SUB Cpcalc(A1,B1,Pp,Plocal,C)
889 C=((Plocal/Pp)*A1)+B1
890 SUBEND
900 SUB Staticpress(P1,Pa,Xvel,6,Pa)
910 Pa=(P1+Pa)*(1-Xvel^2)^(6/(6-1))
920 SUBEND
930 SUB Frefqref(Pp,P1,Qraf,Pq)
940 Fq=(Pp-P1)/Qraf
950 SUBEND

```

B7.6 Subprogram LOSSCALC

```
1      IFILE LOSSCALC
10     ITHIS SUBPROGRAM IS AN ADAPTATION OF SHREEVE'S INTEGRATION ROUTINE
20     I GIVEN IN APPENDIX B OF NPS-57SF73071A
272    SUB Datint(Lowpoint,Hipoint,D(*),Posit(*),Datint)
277    OPTION BASE 1
287    DIM A(100)
297    DIM B(100)
307    DIM C(100)
317    DIM Dint(100)
321    MAT A= (0)
322    MAT B= (0)
323    MAT C= (0)
324    MAT Dint= (0)
325    N=Hipoint-1
326    Nml=N-1
327    FOR I=Lowpoint+1 TO N
337    A(I)=(1/((Posit(I+1)-Posit(I-1)))*(((D(I+1)-D(I))/(Posit(I+1)-Posit(I)))-((
D(I)-D(I-1))/(Posit(I)-Posit(I-1))))
347    B(I)=((D(I)-D(I-1))/(Posit(I)-Posit(I-1)))-((Posit(I)+Posit(I-1))*A(I))
357    C(I)=D(I)-(A(I)*Posit(I)^2)-(B(I)*Posit(I))
360    NEXT I
361    Datint=0
362    FOR I=Lowpoint+1 TO Nml
363    Dint(I)=(A(I)+A(I+1))*(Posit(I+1)^3-Posit(I)^3)/6+(B(I)+B(I+1))*(Posit(I+1)
)^2-Posit(I)^2)/4+(C(I)+C(I+1))*(Posit(I+1)-Posit(I))/2
364    Datint=Datint+Dint(I)
367    NEXT I
377    Dint(1)=A(2)*(Posit(2)^3-Posit(1)^3)/3+B(2)*(Posit(2)^2-Posit(1)^2)/2+C(2)
*(Posit(2)-Posit(1))
387    Dint(N)=A(N)*(Posit(N+1)^3-Posit(N)^3)/3+B(N)*(Posit(N+1)^2-Posit(N)^2)/2+
C(N)*(Posit(N+1)-Posit(N))
397    Datint=Datint+Dint(1)+Dint(N)
407    SUBEND
```

B7.7 Plot Program PREFPQREF

```
1  IPROGRAM PREFPQREF
2  IPROGRAM PLOTS PREF-PT/QREF VS PROBE POSITION
4  MASS STORAGE IS "/CLASSICK/RE00DATA"
7  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
10 ASSIGN @Path1 TO Calcdat$
11 OPTION BASE 1
12 DIM Calc(100,25)
17 MAT Calc= (0)
20 Scan=31
26 ENTER @Path1;Calc(*)
50 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LORG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+I,Y_gdu_max
78 LABEL "Pref-Pt1/Qref VS PROBE DISPLACEMENT"
79 NEXT I
83 DEG
84 LOIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "Pref-Pt1/Qref"
87 LOIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "8LAOE-T0-8LAOE (1n)"
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW 0,3,0,.7
96 AXES .1,.01,0,0,5,10,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LORG 6
100 FOR I=0 TO 3 STEP .5
101 MOVE I,-.01
102 LABEL USING "#,K",I
103 NEXT I
104 LORG 8
105 FOR I=1.0 TO 0 STEP -.1
106 MOVE -.01,I
107 LABEL USING "DO.DD",I
108 NEXT I
109 FOR K=1 TO Scan
113 PLOT Calc(K,1),Calc(K,18)
114 NEXT K
117 END
```

B7.8 Plot Program BETAPOSIT

```
1  IPROGRAM BETAPOSIT
2  IPROGRAM PLOTS BETA VS PROBE POSITION
4  MASS STORAGE IS "/CLASSICK/REDOATA"
7  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
10 ASSIGN @Path1 TO Calcdat$
11 OPTION BASE 1
12 DIM Calc(100,25)
17 MAT Calc= (0)
20 Scan=31
26 ENTER @Path1;Calc(*)
50 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LORG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+I,Y_gdu_max
78 LABEL "BETA1 VS PROBE DISPLACEMENT"
79 NEXT I
83 OEG
84 LOIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "BETA1 (deg)"
87 LOIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "BLADE-TO-BLADE (in)"
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW 0,3,-50,-45
96 AXES .1,.2,0,-50,5,5,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LORG 6
100 FOR I=0 TO 3 STEP .5
101 MOVE I,-50.2
102 LABEL USING "%,K",I
103 NEXT I
104 LORG 8
105 FOR I=-50.0 TO -45.0 STEP 1
106 MOVE -.01,I
107 LABEL USING "DDD.D",I
108 NEXT I
109 FOR K=1 TO Scan
113 PLOT Calc(K,1),-Calc(K,9)
114 NEXT K
117 END
```

B7.9 Plot Program VVREFSPAN

```
1  IPROGRAM VVREFSPAN
2  IPROGRAM PLOTS V1/VREF VS PROBE POSITION FOR A SPAN-WISE SURVEY
4  MASS STORAGE IS "/CLASSICK/REDOATA"
5  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",Calcdat$
6  ASSIGN @Path2 TO Calcdat$
9  OPTION BASE 1
10 DIM Calc(100,25)
11 MAT Calc= (0)
12 Scan=42
14 ENTER @Path2;Calc(*)
50 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LORG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+I,Y_gdu_max
78 LABEL "V1/Vref VS PROBE DISPLACEMENT"
79 NEXT I
83 DEG
84 LDIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "V1/Vref"
87 LDIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "SPAN (in) "
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW -5,5,1,1.5
96 AXES 1,.01,-5,1.0,1,10,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LORG 6
100 FOR I=5 TO -5 STEP -1
101 MOVE I,.99
102 LABEL USING "#,K"iI
103 NEXT I
104 LORG 8
105 FOR I=15 TO 1.0 STEP -.1
106 MOVE -5.05,I
107 LABEL USING "00.00"iI
108 NEXT I
109 FOR K=1 TO Scan
113 PLOT Calc(K,1),Calc(K,7)/Calc(K,14)
114 NEXT K
117 ENO
```

B7.10 Plot Program VVREFUSPAN

```
1  IPROGRAM VVREFUSPAN
2  IPROGRAM PLOTS V2/VREF VS PROBE POSITION FOR UPPER TRAVERSE SPAN-WISE
3  I SURVEYS
5  MASS STORAGE IS "/CLASSICK/REDDATA"
6  INPUT "ENTER THE NAME OF THE REDUCED DATA FILE",CaIcdat$
7  ASSIGN @Path2 TO CaIcdat$
9  OPTION BASE 1
10 DIM CaIc(100,25)
11 MAT CaIc= (0)
12 Scan=38
14 ENTER @Path2,CaIc(*)
50 GINIT
60 PLOTTER IS CRT,"INTERNAL"
70 GRAPHICS ON
73 X_gdu_max=100*MAX(1,RATIO)
74 Y_gdu_max=100*MAX(1,1/RATIO)
75 LONG 6
76 FOR I=-.3 TO .3 STEP .1
77 MOVE X_gdu_max/2+I,Y_gdu_max
78 LABEL "V2/Vref VS PROBE DISPLACEMENT"
79 NEXT I
83 DEG
84 LDIR 90
85 MOVE 0,Y_gdu_max/2
86 LABEL "V2/Vref"
87 LDIR 0
88 MOVE X_gdu_max/2,.1*Y_gdu_max
89 CSIZE 3,1
91 LABEL "SPAN (in) "
92 VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94 FRAME
95 WINDOW -5,5,.5,1.0
96 AXES 1,.01,-5,.5,1,10,2
97 CLIP OFF
98 CSIZE 2.5,.5
99 LONG 6
100 FOR I=5 TO -5 STEP -1
101 MOVE I,.49
102 LABEL USING "%,K",I
103 NEXT I
104 LONG 8
105 FOR I=1.0 TO .5 STEP -.1
106 MOVE -5.05,I
107 LABEL USING "DD.DD",I
108 NEXT I
109 FOR K=1 TO Scan
113 PLOT CaIc(K,1),CaIc(K,7)/CaIc(K,14)
114 NEXT K
117 END
```

B7.11 Plot Program CPBLADEPLOT

```
1      IPROGRAM CPBLADEPLOT
2      IPROGRAM PLOTS MASS AVERAGED BLADE COEFFICIENT OF PRESSURE AGAINST
3      !THE FRACTION OF CORD X/C FROM THE LEADING EDGE.
5      MASS STORAGE IS "/CLASSICK/REDOATA"
7      INPUT "ENTER THE NAME OF THE FILE CONTAINING THE BLADE CP'S",Cpfile$
10     ASSIGN @Path1 TO Cpfile$
11     OPTION BASE 1
12     DIM Cpmassavg(48)
15     DIM Xoc(20)
16     MAT Cpmassavg= (0)
19     DATA 98.8,94.8,90.8,86.8,82.8,78.8,71.5,64.1,56.7,49.3,41.9,34.3,26.9,19.6
,12.2,8.6,4.8,3.2,1.6,0
20     READ Xoc(*)
26     ENTER @Path1,Cpmassavg(*)
54     GINIT
60     PLOTTER IS CRT,"INTERNAL"
70     GRAPHICS ON
73     X_gdu_max=100*MAX(1,RATIO)
74     Y_gdu_max=100*MAX(1,1/RATIO)
75     LOG 6
76     FOR I=-.3 TO .3 STEP .1
77     MOVE X_gdu_max/2+I,Y_gdu_max
78     LABEL "Cp VS PERCENT CHORD"
79     NEXT I
83     DEG
84     LOIR 90
85     MOVE 0,Y_gdu_max/2
86     LABEL "Cp"
87     LOIR 0
88     MOVE X_gdu_max/2,.1*Y_gdu_max
89     CSIZE 3,1
91     LABEL "X/C PERCENT CHORD"
92     VIEWPORT .1*X_gdu_max,.99*X_gdu_max,.15*Y_gdu_max,.9*Y_gdu_max
94     FRAME
95     WINDOW 0,100,1.0,-1.6
96     AXES 5,.2,0,1.0,2,2,2
97     CLIP OFF
98     CSIZE 2.5,.5
99     LOG 6
100    FOR I=0 TO 100 STEP 10
101    MOVE I,1.02
102    LABEL USING "%,K",I
103    NEXT I
104    LOG 8
105    FOR I=-1.6 TO 1.0 STEP .4
106    MOVE -.6,I
107    LABEL USING "DO.DD",I
108    NEXT I
109    FOR N=1 TO 20
113    PLOT Xoc(N),Cpmassavg(N+3)
114    NEXT N
115    FOR N=1 TO 20
116    PLOT Xoc(21-N),Cpmassavg(22+N)
117    NEXT N
119    END
```

B7.12 Program CORRECT A

```
10  IPROGRAM CORRECT A
11  OPTION BASE 1
20  DIM Scldata(1,106)
30  DIM Correctaray(1,106)
35  MAT Correctaray= (0)
40  MAT Scldata= (0)
80  MASS STORAGE IS "/CLASSICK/REDDATA"
90  INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Scfile$
100 INPUT "ENTER THE NAME OF THE CORRECTED FILE",Correctfile$
110 CREATE BOAT Correctfile$,500,848
120 ASSIGN @Path1 TO Scfile$
130 ASSIGN @Path2 TO Correctfile$
140 FOR N=1 TO 49
150 ENTER @Path1,N,Scldata(*)
151 ON ENO @Path1 GOTO Adddata
153 Adddata: IF N=49 THEN
154   Scldata(1,1)=2.000E-2
155   Scldata(1,2)=1.494E+1
156   Scldata(1,3)=1.256E+1
157   Scldata(1,4)=-6.520E+0
158   Scldata(1,5)=7.700E+0
159   Scldata(1,6)=-8.160E-1
160   Scldata(1,7)=-8.280E-1
161   Scldata(1,8)=-3.280E-1
162   Scldata(1,9)=-1.270E+0
163   Scldata(1,10)=1.075E+1
164   Scldata(1,11)=-7.200E+0
165   Scldata(1,12)=1.000E-2
166   Scldata(1,13)=-2.000E-3
167   Scldata(1,14)=-6.000E-3
168   Scldata(1,16)=1.770E+0
169   Scldata(1,15)=3.0
170   Scldata(1,17)=4.561E+2
171   Scldata(1,18)=405.20
172 END IF
173 MAT Correctaray= Scldata
174 OUTPUT @Path2,N,Correctaray(*)
175 NEXT N
192 ASSIGN @Path2 TO Correctfile$
194 FOR N=1 TO 49
195 ENTER @Path2,N,Correctaray(*)
197 PRINT "*****"
198 PRINT "SCAN",N
200 PRINT Correctaray(*)
201 PRINT "*****"
203 NEXT N
210 ENO
```

B7.13 Program CORRECT B

```
10  PROGRAM CORRECT B
11  OPTION PAGE 1
20  DIM Sdata(1,100)
30  DIM Correctaray(1,100)
35  HAI Correctaray= (0)
40  HAI Sdata= (0)
50  PASS STORAGE IS "/CLASSICK/RECDATA"
60  INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Scfile$
100 INPUT "ENTER THE NAME OF THE CORRECTED FILE",CorrectFile$
110 CREATE LOGAL Correctfile$,500,810
120 ASSIGN @Path1 TO Scfile$
130 ASSIGN @Path2 TO Correctfile$
140 FOR N=1 TO 40
150 ENTER @Path1,HISdata(*)
151 IF N=35 THEN Sdata(1,15)=1,95
160 HAI Correctaray= Sdata
164 OUTPUT @Path2,HICorrectaray(*)
166 NEXT N
172 ASSIGN @Path2 TO Correctfile$
181 FOR N=1 TO 40
185 ENTER @Path2,HICorrectaray(1
187 PRINT "*****"
189 PRINT "SCAN",N
200 PRINT Correctaray(*)
201 PRINT "*****"
203 NEXT N
210 END
```

B7.14 Program CORRECT C

```
10 PROGRAM CORRECT C
11 OPTION BASE 1
20 DIM Scldata(1,100)
30 DIM Correctaray(1,100)
40 DIM Correctdata(30)
50 DIM Scldata(0)
50 DATA -3.2,-3.1,-3.0,-2.9,-2.8,-2.7,-2.6,-2.5,-2.4,-2.3,-2.2,-2.1,-2.0,-1.9
,-1.7,-1.5,-1.2,-1.1,-.7,-.5,-.2,.1,.4,.7,1.0,1.3,1.6,1.9,2.1,2.3,2.5,2.6,2.7
70 DATA 2.8,2.9,3.0;3.1,3.2
71 READ Correctdata(*)
80 MASS $PAGE IS "/CLASSICK/REDWINA"
90 INPUT "ENTER THE NAME OF THE FILE TO BE CORRECTED",Sc1file$
100 INPUT "ENTER THE NAME OF THE CORRECTED FILE",Correctfile$
110 CREATE DDAT Correctfile$,500,848
120 ASSIGN @Path1 TO Sc1file$
130 ASSIGN @Path2 TO Correctfile$
140 FOR N=1 TO 30
150 ENTER @Path1,H1Scldata(*)
151 Scldata(1,151)=Correctdata(N)
163 MAT Correctaray= Scldata
164 OUTPUT @Path2,H1Correctaray(*)
166 NEXT N
172 ASSIGN @Path2 TO Correctfile$
184 FOR N=1 TO 30
195 ENTER @Path2,H1Correctaray(*)
197 PRINT "*****"
198 PRINT "SCAN",N
200 PRINT Correctaray(*)
201 PRINT "*****"
203 NEXT N
210 END
```

B7.15 Program PRBCOEF

```

10      I PROGRAM PRECOEF
20      I THIS PROGRAM STORES THE PROBE COEFFICIENTS IN A DATA FILE
30      OPTION BASE 1
40      DIM C(6,6)
50      DATA 1,2,3,4,5,0,2,3,4,5,6,0,3,4,5,6,7,0,4,5,6,7,8,0,0,0,0,0,0,0,0,0,0,0
    ,0
60      READ C(*)
70      PRINT C(*)
80      ISTORE THE DATA INTO A FILE
90      MASS STORAGE IS "/CLASSICK/REDOATA"
100     INPUT "ENTER THE NAME OF THE COEFFICIENT FILE",Reddata$
110     CREATE BDAT Reddata$,1,400
120     ASSIGN @Path1 TO Reddata$
130     OUTPUT @Path1,C(*)
140     IPRINT STORED COEFFICIENT ARRAY
150     ASSIGN @Path1 TO Reddata$
160     ENTER @Path1,C(*)
161     FOR N=1 TO 6
162     PRINT USING "M0.30E-4X";C(N,1),C(N,2),C(N,3),C(N,4),C(N,5),C(N,6)
163     NEXT N
165     END

```

B7.16 Examples of Acquired and Reduced Data

The Scanivalve port and scanner channel assignments for data acquired using program ACQUIRE are shown in Table B1.

An example of the table of survey data output by program ACQUIRE in engineering units ('scaled') is given in Table B2, and the corresponding reduced data output by program CALC is given in Table B3 for an upstream probe survey. Similar results for the downstream survey [survey 6 in Table II] are given in Table B4 and Table B5 respectively.

An example of scaled data output by program ACQUIRE for a surface pressure scan is given in Table B6. The corresponding table of pressure coefficients calculated by program CALC is given in Table B7.

B8. FLEXIBLE DISC INITIALIZATION AND FILE BACKUP

Flexible discs are used to backup the files stored on the computer's hard disc. The file structure used for the present work was designed to allow the contents of each subdirectory to be stored separately from the other subdirectories. Backing up the file system therefore requires separate flexible discs for each subdirectory. Blank discs must be formatted first, using the following steps:

1. Type MSI "/" [Puts system in root directory if not already there.]

TABLE B1. SCANIVALVE PORT AND SCANNER CHANNEL ASSIGNMENTS

5-Hole Probe		SCANNER #2		SCANNER #2	
S.V. # 2	S.V. # 1	ch		ch	
1 P atmospheric	P atmospheric	0	SV1 READ DATA	40	SV1 ADVANCE(step)
2 P calibration	P calibration	1	SV2 " "	41	SV2 " "
3 P plenum	P plenum	2		42	
4 P wall static	20B blade(press)	3		43	
5 P1 (probe)	19B	4		44	
6 P2 "	18B	5		45	SV1 RESET(home)
7 P3 "	17B	6		46	SV2 " "
8 P4 "	16B	7		47	
9 P5 "	15B	8		48	
10 Ptp Prandtl(total)	14B	9		49	
11 Psp Prandtl(static)	13B	10	Tt(plenum)	50	
12 BLANK	12B	11		51	
13 "	11B	12		52	
14 "	10B	13		53	
15 "	9B	14		54	
16 "	8B	15		55	
17 "	7B	16		56	
18 "	6B	17		57	
19 "	5B	18		58	
20 "	4B	19		59	
21 "	3B	20		60	
22 "	2B	21		61	
23 "	1	22		62	
24 "	2T(suction side)	23		63	
25 "	3T	24	YAW XDUCER	64	
26 "	4T	25		65	
27 "	5T	26		66	
28 "	6T	27		67	
29 "	7T	28		68	
30 "	8T	29		69	
31 "	9T	30		70	
32 "	10T	31		71	
33 "	11T	32		72	
34 "	12T	33		73	
35 "	13T	34		74	
36 "	14T	35		75	
37 "	15T	36		76	
38 "	16T	37		77	
39 "	17T	38		78	
40 "	18T	39		79	
41 "	19T				
42 "	20T				
43 "	S1 (partial inst)				
44 "	S2 (suction side)				
45 "	S3				
46 "	P2 (press side)				
47 "	P3				
48 "	TRAILING EDGE				

TABLE B2. UPSTREAM BLADE-TO-BLADE SCALED PROBE
DATA FILE L-4SEPASCL

SCAN	PROBE POSIT	1	2	3	4	5
1	0.00	2.800E-02	1.475E+01	1.177E+01	-6.012E+00	1.010E+01
2	.10	3.400E-02	1.476E+01	1.182E+01	-6.052E+00	1.014E+01
3	.20	2.600E-02	1.476E+01	1.185E+01	-6.146E+00	1.019E+01
4	.30	2.600E-02	1.480E+01	1.167E+01	-6.104E+00	1.017E+01
5	.40	3.200E-02	1.479E+01	1.186E+01	-6.154E+00	1.015E+01
6	.50	2.400E-02	1.484E+01	1.195E+01	-6.112E+00	1.021E+01
7	.60	3.600E-02	1.482E+01	1.197E+01	-6.134E+00	1.027E+01
8	.70	2.400E-02	1.483E+01	1.200E+01	-6.156E+00	1.028E+01
9	.80	2.600E-02	1.484E+01	1.203E+01	-6.166E+00	1.025E+01
10	.90	4.200E-02	1.485E+01	1.201E+01	-6.218E+00	1.028E+01
11	1.00	3.400E-02	1.487E+01	1.203E+01	-6.160E+00	1.024E+01
12	1.10	3.600E-02	1.488E+01	1.209E+01	-6.246E+00	1.026E+01
13	1.20	4.800E-02	1.490E+01	1.212E+01	-6.282E+00	1.025E+01
14	1.30	3.400E-02	1.491E+01	1.215E+01	-6.264E+00	1.027E+01
15	1.40	3.200E-02	1.489E+01	1.219E+01	-6.334E+00	1.032E+01
16	1.50	3.600E-02	1.492E+01	1.225E+01	-6.266E+00	1.036E+01
17	1.60	3.600E-02	1.491E+01	1.225E+01	-6.358E+00	1.037E+01
18	1.70	3.400E-02	1.494E+01	1.230E+01	-6.280E+00	1.047E+01
19	1.80	3.600E-02	1.493E+01	1.233E+01	-6.356E+00	1.046E+01
20	1.90	4.200E-02	1.493E+01	1.232E+01	-6.386E+00	1.044E+01
21	2.00	4.400E-02	1.492E+01	1.235E+01	-6.374E+00	1.049E+01
22	2.10	4.000E-02	1.492E+01	1.247E+01	-6.490E+00	1.052E+01
23	2.20	4.200E-02	1.493E+01	1.249E+01	-6.420E+00	1.051E+01
24	2.30	3.400E-02	1.492E+01	1.262E+01	-6.518E+00	1.059E+01
25	2.40	4.800E-02	1.489E+01	1.266E+01	-6.574E+00	1.059E+01
26	2.50	3.600E-02	1.490E+01	1.275E+01	-6.586E+00	1.059E+01
27	2.60	4.000E-02	1.466E+01	1.278E+01	-6.562E+00	1.080E+01
28	2.70	4.200E-02	1.490E+01	1.276E+01	-6.586E+00	1.058E+01
29	2.80	4.600E-02	1.490E+01	1.276E+01	-6.620E+00	1.056E+01
30	2.90	4.800E-02	1.488E+01	1.277E+01	-6.632E+00	1.055E+01
31	3.00	4.600E-02	1.489E+01	1.273E+01	-6.660E+00	1.059E+01

SCAN	6	7	8	9	10	11
1	-7.496E+00	-7.542E+00	-6.816E+00	-8.432E+00	1.014E+01	-6.746E+00
2	-7.516E+00	-7.542E+00	-6.816E+00	-8.500E+00	1.021E+01	-6.796E+00
3	-7.578E+00	-7.602E+00	-6.750E+00	-8.576E+00	1.023E+01	-6.794E+00
4	-7.558E+00	-7.542E+00	-6.706E+00	-8.612E+00	1.025E+01	-6.782E+00
5	-7.566E+00	-7.578E+00	-6.620E+00	-8.660E+00	1.025E+01	-6.814E+00
6	-7.592E+00	-7.598E+00	-6.662E+00	-8.714E+00	1.028E+01	-6.820E+00
7	-7.594E+00	-7.812E+00	-6.650E+00	-8.816E+00	1.032E+01	-6.822E+00
8	-7.626E+00	-7.826E+00	-6.598E+00	-8.880E+00	1.038E+01	-6.816E+00
9	-7.630E+00	-7.640E+00	-6.582E+00	-8.862E+00	1.035E+01	-6.860E+00
10	-7.640E+00	-7.662E+00	-6.586E+00	-8.862E+00	1.034E+01	-6.850E+00
11	-7.670E+00	-7.626E+00	-6.592E+00	-8.920E+00	1.042E+01	-6.904E+00
12	-7.656E+00	-7.698E+00	-6.684E+00	-8.914E+00	1.044E+01	-6.898E+00
13	-7.682E+00	-7.696E+00	-6.670E+00	-8.870E+00	1.043E+01	-6.922E+00
14	-7.674E+00	-7.666E+00	-6.694E+00	-8.834E+00	1.046E+01	-6.924E+00
15	-7.714E+00	-7.700E+00	-6.764E+00	-8.816E+00	1.053E+01	-6.974E+00
16	-7.766E+00	-7.758E+00	-6.834E+00	-8.804E+00	1.055E+01	-7.008E+00
17	-7.726E+00	-7.726E+00	-6.892E+00	-8.842E+00	1.057E+01	-7.050E+00
18	-7.744E+00	-7.772E+00	-6.896E+00	-8.870E+00	1.060E+01	-7.042E+00
19	-7.788E+00	-7.772E+00	-6.970E+00	-8.826E+00	1.062E+01	-7.056E+00
20	-7.732E+00	-7.776E+00	-6.920E+00	-8.622E+00	1.061E+01	-7.102E+00
21	-7.788E+00	-7.776E+00	-6.950E+00	-8.888E+00	1.065E+01	-7.076E+00
22	-7.816E+00	-7.840E+00	-6.984E+00	-8.876E+00	1.073E+01	-7.146E+00
23	-7.842E+00	-7.842E+00	-6.970E+00	-8.978E+00	1.073E+01	-7.172E+00
24	-7.914E+00	-7.930E+00	-7.082E+00	-9.066E+00	1.092E+01	-7.250E+00
25	-7.960E+00	-7.932E+00	-7.040E+00	-9.140E+00	1.092E+01	-7.220E+00
26	-7.946E+00	-7.956E+00	-6.974E+00	-9.156E+00	1.096E+01	-7.284E+00
27	-7.976E+00	-7.986E+00	-6.912E+00	-9.220E+00	1.098E+01	-7.310E+00
28	-7.968E+00	-7.990E+00	-6.938E+00	-9.256E+00	1.099E+01	-7.304E+00
29	-7.996E+00	-8.006E+00	-6.652E+00	-9.274E+00	1.103E+01	-7.316E+00
30	-7.984E+00	-7.976E+00	-6.830E+00	-9.326E+00	1.098E+01	-7.324E+00
31	-7.966E+00	-8.004E+00	-6.866E+00	-9.336E+00	1.107E+01	-7.366E+00

TABLE B2 (CONT.). UPSTREAM BLADE-TO-BLADE SCALED
PROBE DATA FILE L-4SEPASCL

SCAN	12	13	14	YAW DEG	TEMP (R)	ATMOS PRESS
1	-6.000E-03	-1.660E-01	-2.460E-01	4.892E+01	4.607E+02	405.47
2	0.000E+00	-1.660E-01	-2.620E-01	4.870E+01	4.603E+02	405.47
3	0.000E+00	-1.660E-01	-2.620E-01	4.867E+01	4.602E+02	405.47
4	2.000E-03	-1.600E-01	-2.620E-01	4.665E+01	4.600E+02	405.47
5	6.000E-03	-1.840E-01	-2.560E-01	4.866E+01	4.596E+02	405.47
6	-4.000E-03	-1.660E-01	-2.600E-01	4.667E+01	4.557E+02	405.47
7	-8.000E-03	-1.660E-01	-2.560E-01	4.866E+01	4.596E+02	405.47
8	1.600E-02	-1.760E-01	-2.480E-01	4.866E+01	4.554E+02	405.47
9	1.600E-02	-1.500E-01	-2.520E-01	4.867E+01	4.595E+02	405.47
10	-1.400E-02	-1.840E-01	-2.620E-01	4.866E+01	4.596E+02	405.47
11	2.000E-03	-1.660E-01	-2.520E-01	4.866E+01	4.595E+02	405.47
12	-2.000E-03	-1.760E-01	-2.620E-01	4.865E+01	4.554E+02	405.47
13	-1.600E-02	-2.020E-01	-2.840E-01	4.867E+01	4.593E+02	405.47
14	-1.000E-02	-1.760E-01	-2.560E-01	4.867E+01	4.595E+02	405.47
15	4.000E-03	-1.500E-01	-2.420E-01	4.866E+01	4.593E+02	405.47
16	2.000E-03	-1.960E-01	-2.620E-01	4.665E+01	4.592E+02	405.47
17	8.000E-03	-1.660E-01	-2.660E-01	4.867E+01	4.593E+02	405.47
18	1.200E-02	-1.620E-01	-2.680E-01	4.864E+01	4.593E+02	405.47
19	4.000E-03	-1.780E-01	-2.580E-01	4.866E+01	4.590E+02	405.47
20	0.000E+00	-1.780E-01	-2.660E-01	4.690E+01	4.554E+02	405.47
21	4.000E-03	-1.840E-01	-2.740E-01	4.665E+01	4.554E+02	405.47
22	1.600E-02	-1.700E-01	-2.500E-01	4.666E+01	4.595E+02	405.47
23	4.000E-03	-1.920E-01	-2.760E-01	4.864E+01	4.596E+02	405.47
24	2.000E-05	-1.620E-01	-2.540E-01	4.875E+01	4.601E+02	405.47
25	6.939E-18	-1.720E-01	-2.620E-01	4.866E+01	4.603E+02	405.47
26	1.400E-02	-1.820E-01	-2.480E-01	4.865E+01	4.603E+02	405.47
27	6.000E-03	-1.740E-01	-2.400E-01	4.865E+01	4.603E+02	405.47
28	2.000E-03	-1.660E-01	-2.560E-01	4.867E+01	4.602E+02	405.47
29	0.000E+00	-1.740E-01	-2.500E-01	4.663E+01	4.604E+02	405.47
30	2.000E-03	-1.960E-01	-2.700E-01	4.664E+01	4.607E+02	405.47
31	-2.000E-03	-1.860E-01	-2.560E-01	4.879E+01	4.606E+02	405.47

TABLE B3. UPSTREAM BLADE-TO-BLADE REDUCED PROBE
DATA FILE L-4SEPACALC

SCAN	PR8 POSIT	BETA	GAMMA	PHI	Xvel	Xref
1	0.00	4.240E-02	9.172E-02	-1.550E-03	1.092E-01	9.023E-02
2	.10	4.252E-02	9.529E-02	-3.445E-03	1.093E-01	9.044E-02
3	.20	4.277E-02	1.028E-01	-7.483E-03	1.096E-01	9.068E-02
4	.30	4.263E-02	1.076E-01	-1.012E-02	1.093E-01	9.061E-02
5	.40	4.263E-02	1.163E-01	-1.492E-02	1.092E-01	9.057E-02
6	.50	4.283E-02	1.153E-01	-1.433E-02	1.095E-01	9.091E-02
7	.60	4.299E-02	1.212E-01	-1.759E-02	1.096E-01	9.098E-02
8	.70	4.306E-02	1.276E-01	-2.116E-02	1.097E-01	9.108E-02
9	.80	4.303E-02	1.275E-01	-2.111E-02	1.096E-01	9.119E-02
10	.90	4.312E-02	1.270E-01	-2.081E-02	1.097E-01	9.113E-02
11	1.00	4.304E-02	1.301E-01	-2.260E-02	1.096E-01	9.121E-02
12	1.10	4.320E-02	1.242E-01	-1.923E-02	1.099E-01	9.145E-02
13	1.20	4.316E-02	1.226E-01	-1.836E-02	1.099E-01	9.153E-02
14	1.30	4.318E-02	1.192E-01	-1.646E-02	1.099E-01	9.164E-02
15	1.40	4.335E-02	1.139E-01	-1.345E-02	1.102E-01	9.182E-02
16	1.50	4.358E-02	1.087E-01	-1.056E-02	1.106E-01	9.203E-02
17	1.60	4.353E-02	1.077E-01	-1.003E-02	1.105E-01	9.203E-02
18	1.70	4.383E-02	1.083E-01	-1.029E-02	1.109E-01	9.219E-02
19	1.80	4.389E-02	1.017E-01	-6.635E-03	1.111E-01	9.233E-02
20	1.90	4.375E-02	1.045E-01	-8.234E-03	1.109E-01	9.229E-02
21	2.00	4.394E-02	1.060E-01	-9.034E-03	1.111E-01	9.240E-02
22	2.10	4.411E-02	1.031E-01	-7.393E-03	1.114E-01	9.283E-02
23	2.20	4.412E-02	1.094E-01	-1.087E-02	1.113E-01	9.291E-02
24	2.30	4.450E-02	1.093E-01	-1.077E-02	1.118E-01	9.338E-02
25	2.40	4.455E-02	1.133E-01	-1.297E-02	1.118E-01	9.352E-02
26	2.50	4.457E-02	1.178E-01	-1.546E-02	1.118E-01	9.377E-02
27	2.60	4.466E-02	1.242E-01	-1.905E-02	1.118E-01	9.388E-02
28	2.70	4.462E-02	1.250E-01	-1.949E-02	1.118E-01	9.388E-02
29	2.80	4.461E-02	1.305E-01	-2.263E-02	1.117E-01	9.397E-02
30	2.90	4.451E-02	1.348E-01	-2.507E-02	1.115E-01	9.391E-02
31	3.00	4.467E-02	1.318E-01	-2.336E-02	1.117E-01	9.400E-02
SCAN	Vel	Uref	Q	Qref	MACH	YAW DEG
1	2.568E+02	2.123E+02	1.682E+01	1.165E+01	2.455E-01	4.892E+01
2	2.570E+02	2.127E+02	1.686E+01	1.170E+01	2.459E-01	4.870E+01
3	2.576E+02	2.132E+02	1.695E+01	1.177E+01	2.465E-01	4.867E+01
4	2.570E+02	2.130E+02	1.687E+01	1.175E+01	2.459E-01	4.865E+01
5	2.566E+02	2.128E+02	1.684E+01	1.174E+01	2.457E-01	4.866E+01
6	2.573E+02	2.136E+02	1.692E+01	1.183E+01	2.463E-01	4.867E+01
7	2.576E+02	2.138E+02	1.697E+01	1.185E+01	2.467E-01	4.866E+01
8	2.576E+02	2.140E+02	1.697E+01	1.187E+01	2.467E-01	4.866E+01
9	2.575E+02	2.143E+02	1.696E+01	1.190E+01	2.466E-01	4.867E+01
10	2.579E+02	2.142E+02	1.700E+01	1.189E+01	2.469E-01	4.866E+01
11	2.575E+02	2.143E+02	1.695E+01	1.191E+01	2.465E-01	4.866E+01
12	2.581E+02	2.148E+02	1.704E+01	1.197E+01	2.472E-01	4.865E+01
13	2.581E+02	2.150E+02	1.703E+01	1.199E+01	2.471E-01	4.867E+01
14	2.583E+02	2.153E+02	1.705E+01	1.202E+01	2.473E-01	4.867E+01
15	2.589E+02	2.157E+02	1.715E+01	1.207E+01	2.480E-01	4.865E+01
16	2.598E+02	2.162E+02	1.727E+01	1.212E+01	2.488E-01	4.865E+01
17	2.597E+02	2.162E+02	1.725E+01	1.212E+01	2.487E-01	4.867E+01
18	2.606E+02	2.166E+02	1.737E+01	1.217E+01	2.496E-01	4.864E+01
19	2.609E+02	2.168E+02	1.742E+01	1.220E+01	2.500E-01	4.866E+01
20	2.605E+02	2.168E+02	1.735E+01	1.219E+01	2.495E-01	4.865E+01
21	2.611E+02	2.171E+02	1.743E+01	1.222E+01	2.500E-01	4.865E+01
22	2.617E+02	2.181E+02	1.751E+01	1.234E+01	2.506E-01	4.866E+01
23	2.616E+02	2.184E+02	1.749E+01	1.236E+01	2.505E-01	4.864E+01
24	2.629E+02	2.196E+02	1.765E+01	1.248E+01	2.516E-01	4.875E+01
25	2.630E+02	2.199E+02	1.765E+01	1.252E+01	2.517E-01	4.866E+01
26	2.629E+02	2.205E+02	1.764E+01	1.259E+01	2.516E-01	4.865E+01
27	2.630E+02	2.208E+02	1.765E+01	1.262E+01	2.517E-01	4.865E+01
28	2.628E+02	2.207E+02	1.763E+01	1.262E+01	2.515E-01	4.867E+01
29	2.626E+02	2.210E+02	1.760E+01	1.264E+01	2.513E-01	4.863E+01
30	2.623E+02	2.209E+02	1.754E+01	1.263E+01	2.508E-01	4.864E+01
31	2.629E+02	2.211E+02	1.762E+01	1.265E+01	2.514E-01	4.879E+01

TABLE B3 (CONT.). UPSTREAM BLADE-TO-BLADE REDUCED
PROBE DATA FILE L-4SEPACALC

SCAN	Pref-Pt/Qref
1	1.432E-01
2	1.436E-01
3	1.445E-01
4	1.449E-01
5	1.459E-01
6	1.473E-01
7	1.435E-01
8	1.447E-01
9	1.491E-01
10	1.459E-01
11	1.502E-01
12	1.514E-01
13	1.553E-01
14	1.561E-01
15	1.557E-01
16	1.561E-01
17	1.549E-01
18	1.499E-01
19	1.521E-01
20	1.544E-01
21	1.522E-01
22	1.579E-01
23	1.604E-01
24	1.626E-01
25	1.655E-01
26	1.698E-01
27	1.712E-01
28	1.731E-01
29	1.762E-01
30	1.758E-01
31	1.742E-01

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ENSEMBLE AVERAGES

PPAUG	PAAUG	TEMPAUG	XREFAUG	VREFAUG	QREFAUG
1.227E+01	405.47E+00	459.78	9.210E-02	2.165E+02	1.214E+01

TABLE B4. DOWNSTREAM BLADE-TO-BLADE SCALED
PROBE DATA FILE U-SEPASCL

SCAN	PROBE POSIT	1	2	3	4	5	6	7
1	0.00	3.200E-02	1.498E+01	1.088E+01	-5.584E+00	6.946E+00	-6.880E-01	-6.920E-01
2	.10	2.600E-02	1.501E+01	1.081E+01	-5.626E+00	6.648E+00	-6.700E-01	-6.840E-01
3	.20	3.800E-02	1.499E+01	1.074E+01	-5.614E+00	5.964E+00	-6.440E-01	-6.680E-01
4	.30	3.000E-02	1.501E+01	1.074E+01	-5.602E+00	5.504E+00	-6.280E-01	-6.280E-01
5	.40	3.800E-02	1.498E+01	1.072E+01	-5.576E+00	5.058E+00	-6.080E-01	-6.080E-01
6	.50	4.200E-02	1.499E+01	1.072E+01	-5.568E+00	4.788E+00	-5.940E-01	-5.940E-01
7	.55	4.400E-02	1.497E+01	1.071E+01	-5.550E+00	4.738E+00	-6.020E-01	-6.120E-01
8	.60	3.600E-02	1.500E+01	1.070E+01	-5.576E+00	4.728E+00	-6.000E-01	-6.120E-01
9	.65	4.800E-02	1.501E+01	1.068E+01	-5.548E+00	4.720E+00	-6.340E-01	-6.400E-01
10	.70	4.400E-02	1.500E+01	1.069E+01	-5.490E+00	4.836E+00	-6.300E-01	-6.520E-01
11	.75	3.600E-02	1.500E+01	1.072E+01	-5.574E+00	4.968E+00	-6.300E-01	-6.660E-01
12	.80	4.400E-02	1.498E+01	1.073E+01	-5.588E+00	5.160E+00	-6.880E-01	-6.740E-01
13	.85	4.000E-02	1.501E+01	1.105E+01	-5.784E+00	5.512E+00	-7.200E-01	-7.300E-01
14	.90	4.000E-02	1.499E+01	1.128E+01	-5.824E+00	5.878E+00	-7.780E-01	-7.580E-01
15	.95	3.400E-02	1.502E+01	1.138E+01	-5.926E+00	6.276E+00	-8.020E-01	-7.960E-01
16	1.00	3.200E-02	1.500E+01	1.156E+01	-6.006E+00	6.660E+00	-8.020E-01	-8.260E-01
17	1.05	2.800E-02	1.508E+01	1.163E+01	-5.972E+00	7.066E+00	-8.220E-01	-8.300E-01
18	1.10	4.200E-02	1.509E+01	1.170E+01	-6.064E+00	7.492E+00	-8.680E-01	-8.760E-01
19	1.15	4.000E-02	1.507E+01	1.174E+01	-6.108E+00	7.822E+00	-8.720E-01	-8.900E-01
20	1.20	4.400E-02	1.505E+01	1.180E+01	-6.116E+00	8.214E+00	-8.760E-01	-8.880E-01
21	1.25	3.400E-02	1.504E+01	1.187E+01	-6.118E+00	8.550E+00	-9.020E-01	-8.840E-01
22	1.30	3.800E-02	1.503E+01	1.190E+01	-6.180E+00	8.828E+00	-8.820E-01	-8.860E-01
23	1.35	4.800E-02	1.503E+01	1.191E+01	-6.176E+00	9.130E+00	-8.880E-01	-8.960E-01
24	1.40	5.600E-02	1.499E+01	1.186E+01	-6.156E+00	9.238E+00	-8.900E-01	-8.820E-01
25	1.45	4.200E-02	1.500E+01	1.192E+01	-6.154E+00	9.468E+00	-8.640E-01	-8.740E-01
26	1.50	4.600E-02	1.498E+01	1.191E+01	-6.172E+00	9.624E+00	-8.540E-01	-8.680E-01
27	1.55	3.600E-02	1.501E+01	1.197E+01	-6.208E+00	9.748E+00	-8.480E-01	-8.420E-01
28	1.60	5.200E-02	1.495E+01	1.201E+01	-6.230E+00	9.790E+00	-8.500E-01	-8.560E-01
29	1.65	4.000E-02	1.497E+01	1.199E+01	-6.200E+00	9.830E+00	-8.100E-01	-8.300E-01
30	1.70	4.000E-02	1.497E+01	1.207E+01	-6.264E+00	9.852E+00	-8.240E-01	-8.400E-01
31	1.75	4.200E-02	1.498E+01	1.206E+01	-6.230E+00	9.836E+00	-8.140E-01	-8.460E-01
32	1.80	4.600E-02	1.497E+01	1.207E+01	-6.334E+00	9.958E+00	-8.220E-01	-8.160E-01
33	1.85	4.000E-02	1.499E+01	1.212E+01	-6.320E+00	9.920E+00	-8.100E-01	-8.040E-01
34	1.90	2.600E-02	1.500E+01	1.215E+01	-6.376E+00	1.009E+01	-8.180E-01	-8.120E-01
35	2.00	4.400E-02	1.497E+01	1.216E+01	-6.338E+00	9.996E+00	-8.180E-01	-8.400E-01
36	2.00	4.600E-02	1.495E+01	1.221E+01	-6.366E+00	9.988E+00	-8.200E-01	-8.480E-01
37	2.05	4.000E-02	1.497E+01	1.226E+01	-6.368E+00	1.004E+01	-8.180E-01	-8.420E-01
38	2.10	4.000E-02	1.496E+01	1.226E+01	-6.348E+00	9.976E+00	-8.160E-01	-8.160E-01
39	2.15	4.400E-02	1.496E+01	1.228E+01	-6.386E+00	1.005E+01	-8.120E-01	-8.320E-01
40	2.20	3.600E-02	1.496E+01	1.230E+01	-6.442E+00	1.004E+01	-7.980E-01	-8.180E-01
41	2.25	3.800E-02	1.495E+01	1.230E+01	-6.458E+00	9.982E+00	-8.300E-01	-8.220E-01
42	2.35	3.000E-02	1.497E+01	1.238E+01	-6.432E+00	9.952E+00	-8.280E-01	-8.340E-01
43	2.45	4.800E-02	1.494E+01	1.239E+01	-6.456E+00	9.812E+00	-8.360E-01	-8.600E-01
44	2.55	3.800E-02	1.495E+01	1.240E+01	-6.512E+00	9.568E+00	-8.300E-01	-8.360E-01
45	2.65	2.800E-02	1.496E+01	1.246E+01	-6.480E+00	9.304E+00	-8.120E-01	-8.160E-01
46	2.75	3.600E-02	1.496E+01	1.246E+01	-6.508E+00	8.848E+00	-8.500E-01	-8.740E-01
47	2.85	4.000E-02	1.493E+01	1.248E+01	-6.506E+00	8.528E+00	-8.600E-01	-8.280E-01
48	2.95	2.800E-02	1.495E+01	1.254E+01	-6.528E+00	7.950E+00	-8.160E-01	-8.280E-01

TABLE B4 (CONT.). DOWNSTREAM BLADE-TO-BLADE SCALED
PROBE DATA FILE U-4SEPASCL

SCAN	9	10	11	12	13	14	YAW DEG	TEMP (R)	ATMOS PRESS
1	-3.500E-01	-1.026E+00	0.332E+00	-0.200E+00	0.000E+00	-0.000E-03	0.000E+00	2.007E+00	4.557E+02
2	-3.100E-01	-9.600E-01	0.310E+00	-0.170E+00	-1.200E-02	1.000E-02	0.000E-03	2.010E+00	4.556E+02
3	-3.040E-01	-0.700E-01	0.202E+00	-0.166E+00	-1.000E-02	-0.000E-03	-1.000E-02	2.007E+00	4.555E+02
4	-3.400E-01	-0.240E-01	0.270E+00	-0.170E+00	4.000E-03	0.000E-03	1.400E-02	1.763E+00	4.556E+02
5	-3.240E-01	-0.020E-01	0.230E+00	-0.164E+00	-1.000E-02	2.000E-03	-2.000E-03	1.757E+00	4.556E+02
6	-3.140E-01	-0.900E-01	0.210E+00	-0.154E+00	-1.200E-02	-0.000E-03	-3.000E-02	2.004E+00	4.556E+02
7	-3.060E-01	-0.020E-01	0.230E+00	-0.170E+00	-1.200E-02	-1.000E-02	-1.000E-02	2.264E+00	4.556E+02
8	-3.520E-01	-0.900E-01	0.230E+00	-0.124E+00	0.000E+00	0.000E-03	-1.000E-02	2.250E+00	4.556E+02
9	-3.520E-01	-0.100E-01	0.202E+00	-0.136E+00	-1.200E-02	-2.000E-02	-2.200E-02	2.531E+00	4.556E+02
10	-3.500E-01	-0.540E-01	0.100E+00	-0.106E+00	-1.000E-02	-4.000E-03	0.000E+00	2.624E+00	4.556E+02
11	-3.040E-01	-0.420E-01	0.240E+00	-0.110E+00	-1.000E-02	2.000E-03	4.000E-03	2.700E+00	4.556E+02
12	-3.020E-01	-0.020E-01	0.254E+00	-0.160E+00	-1.000E-02	-1.400E-02	-0.000E-03	2.700E+00	4.557E+02
13	-4.040E-01	-1.036E+00	0.554E+00	-0.310E+00	-0.000E-03	-1.000E-02	-1.400E-02	3.026E+00	4.557E+02
14	-4.260E-01	-1.074E+00	0.002E+00	-0.442E+00	-1.200E-02	-0.000E-03	-2.000E-03	3.296E+00	4.557E+02
15	-4.360E-01	-1.100E+00	0.702E+00	-0.620E+00	-0.000E-03	-4.000E-03	-0.000E-03	3.275E+00	4.557E+02
16	-4.400E-01	-1.170E+00	0.952E+00	-0.600E+00	-4.000E-03	4.000E-03	-0.000E-03	3.554E+00	4.558E+02
17	-4.260E-01	-1.110E+00	0.004E+00	-0.040E+00	-1.400E-02	0.000E-03	2.000E-03	3.550E+00	4.558E+02
18	-4.320E-01	-1.162E+00	1.007E+01	-0.714E+00	-0.000E-03	-2.000E-03	-0.000E-03	3.540E+00	4.558E+02
19	-4.460E-01	-1.202E+00	1.013E+01	-0.722E+00	-2.000E-02	-1.400E-02	-1.200E-02	3.556E+00	4.557E+02
20	-4.460E-01	-1.164E+00	1.016E+01	-0.604E+00	-1.400E-02	-4.000E-03	2.000E-03	3.294E+00	4.558E+02
21	-4.360E-01	-1.320E+00	1.022E+01	-0.002E+00	0.000E-03	4.000E-03	-4.000E-03	3.201E+00	4.557E+02
22	-4.100E-01	-1.214E+00	1.026E+01	-0.732E+00	2.000E-03	4.000E-03	-0.000E-03	3.204E+00	4.558E+02
23	-3.940E-01	-1.226E+00	1.027E+01	-0.704E+00	-2.200E-02	-0.000E-03	-1.400E-02	3.296E+00	4.558E+02
24	-3.920E-01	-1.174E+00	1.022E+01	-0.772E+00	-2.400E-02	-1.600E-02	-1.200E-02	3.205E+00	4.559E+02
25	-3.700E-01	-1.170E+00	1.027E+01	-0.020E+00	-1.000E-02	-2.000E-03	6.000E-03	3.296E+00	4.559E+02
26	-3.500E-01	-1.100E+00	1.031E+01	-0.060E+00	-1.000E-02	-1.600E-02	-1.200E-02	3.023E+00	4.559E+02
27	-3.400E-01	-1.104E+00	1.035E+01	-0.026E+00	-4.000E-03	-6.000E-03	0.000E+00	3.039E+00	4.559E+02
28	-3.340E-01	-1.210E+00	1.034E+01	-6.030E+00	-0.000E-03	-1.200E-02	-1.200E-02	3.041E+00	4.558E+02
29	-3.300E-01	-1.202E+00	1.037E+01	-0.954E+00	-0.000E-03	-1.200E-02	-0.000E-03	3.024E+00	4.560E+02
30	-5.950E-01	-1.370E+00	1.039E+01	-0.092E+00	-2.200E-02	-6.000E-03	-0.000E-03	3.036E+00	4.559E+02
31	-2.040E-01	-1.552E+00	1.036E+01	-0.010E+00	-2.400E-02	-1.200E-02	-1.200E-02	3.036E+00	4.558E+02
32	-3.740E-01	-1.386E+00	1.040E+01	-0.076E+00	4.000E-03	-4.000E-03	-1.600E-02	2.776E+00	4.558E+02
33	-2.940E-01	-1.210E+00	1.043E+01	-7.012E+00	2.000E-03	-2.000E-03	0.000E+00	2.772E+00	4.558E+02
34	-1.840E-01	-1.544E+00	1.044E+01	-6.042E+00	1.000E-02	1.400E-02	0.000E+00	2.702E+00	4.558E+02
35	-1.680E-01	-1.566E+00	1.040E+01	-0.090E+00	-1.000E-02	-1.400E-02	-1.200E-02	2.770E+00	4.559E+02
36	-1.060E-01	-1.504E+00	1.047E+01	-7.040E+00	-1.000E-02	-3.200E-02	-0.000E-03	2.773E+00	4.561E+02
37	-3.560E-01	-1.370E+00	1.052E+01	-7.044E+00	2.000E-03	-1.400E-02	-3.200E-02	2.701E+00	4.562E+02
38	-4.160E-01	-1.406E+00	1.053E+01	-7.052E+00	0.039E+00	-4.000E-03	2.000E-03	2.707E+00	4.562E+02
39	-2.700E-01	-1.262E+00	1.054E+01	-7.060E+00	-1.600E-02	-1.200E-02	-1.000E-02	2.711E+00	4.561E+02
40	-3.460E-01	-1.390E+00	1.060E+01	-7.060E+00	0.000E-03	-6.000E-03	-0.000E-03	2.704E+00	4.560E+02
41	-2.540E-01	-1.240E+00	1.062E+01	-7.000E+00	4.000E-03	-2.000E-03	-4.000E-03	2.536E+00	4.561E+02
42	-9.200E-02	-1.602E+00	1.064E+01	-7.100E+00	-0.000E-03	-4.000E-03	-4.000E-03	2.572E+00	4.561E+02
43	-1.220E-01	-1.642E+00	1.066E+01	-7.122E+00	-1.400E-02	-1.400E-02	-1.600E-02	2.537E+00	4.560E+02
44	-5.300E-01	-1.472E+00	1.060E+01	-7.150E+00	-1.000E-02	-4.000E-03	-2.000E-03	2.257E+00	4.561E+02
45	-2.620E-01	-1.396E+00	1.069E+01	-7.106E+00	-4.000E-03	-2.000E-03	-4.000E-03	2.270E+00	4.560E+02
46	-3.340E-01	-1.400E+00	1.075E+01	-7.200E+00	-4.000E-03	-6.000E-03	-1.400E-02	2.027E+00	4.561E+02
47	-3.240E-01	-1.294E+00	1.071E+01	-7.164E+00	-4.000E-03	-0.000E-03	-4.000E-03	1.751E+00	4.561E+02
48	-3.300E-01	-1.270E+00	1.070E+01	-7.190E+00	1.000E-02	-2.000E-03	-0.000E-03	1.700E+00	4.561E+02

TABLE B5. DOWNSTREAM BLADE-TO-BLADE REDUCED PROBE
DATA FILE U-4SEPACALC

SCAN	Vel	Vref	Q	Qref	MACH	YAW DEG
1	1.673E+02	2.032E+02	7.277E+00	1.078E+01	1.603E-01	2.007E+00
2	1.640E+02	2.026E+02	6.992E+00	1.071E+01	1.571E-01	2.010E+00
3	1.560E+02	2.019E+02	6.332E+00	1.064E+01	1.495E-01	2.007E+00
4	1.504E+02	2.019E+02	5.880E+00	1.064E+01	1.440E-01	1.763E+00
5	1.446E+02	2.017E+02	5.434E+00	1.062E+01	1.385E-01	1.757E+00
6	1.409E+02	2.017E+02	5.157E+00	1.062E+01	1.349E-01	2.004E+00
7	1.405E+02	2.016E+02	5.130E+00	1.061E+01	1.346E-01	2.264E+00
8	1.403E+02	2.015E+02	5.112E+00	1.060E+01	1.343E-01	2.258E+00
9	1.406E+02	2.013E+02	5.135E+00	1.058E+01	1.346E-01	2.531E+00
10	1.423E+02	2.014E+02	5.260E+00	1.059E+01	1.363E-01	2.624E+00
11	1.440E+02	2.017E+02	5.384E+00	1.062E+01	1.379E-01	2.788E+00
12	1.468E+02	2.018E+02	5.598E+00	1.063E+01	1.406E-01	2.780E+00
13	1.516E+02	2.048E+02	5.974E+00	1.095E+01	1.452E-01	3.026E+00
14	1.564E+02	2.068E+02	6.359E+00	1.117E+01	1.498E-01	3.296E+00
15	1.613E+02	2.077E+02	6.759E+00	1.127E+01	1.545E-01	3.275E+00
16	1.656E+02	2.094E+02	7.125E+00	1.144E+01	1.586E-01	3.554E+00
17	1.700E+02	2.100E+02	7.511E+00	1.151E+01	1.628E-01	3.550E+00
18	1.747E+02	2.106E+02	7.939E+00	1.158E+01	1.674E-01	3.540E+00
19	1.780E+02	2.110E+02	8.245E+00	1.162E+01	1.706E-01	3.556E+00
20	1.818E+02	2.115E+02	8.601E+00	1.168E+01	1.742E-01	3.294E+00
21	1.850E+02	2.121E+02	8.911E+00	1.175E+01	1.773E-01	3.281E+00
22	1.875E+02	2.123E+02	9.155E+00	1.177E+01	1.797E-01	3.284E+00
23	1.903E+02	2.125E+02	9.435E+00	1.179E+01	1.825E-01	3.296E+00
24	1.913E+02	2.120E+02	9.528E+00	1.174E+01	1.834E-01	3.285E+00
25	1.932E+02	2.125E+02	9.721E+00	1.179E+01	1.852E-01	3.296E+00
26	1.945E+02	2.125E+02	9.855E+00	1.178E+01	1.865E-01	3.023E+00
27	1.954E+02	2.130E+02	9.953E+00	1.185E+01	1.874E-01	3.039E+00
28	1.959E+02	2.134E+02	9.998E+00	1.189E+01	1.878E-01	3.041E+00
29	1.960E+02	2.132E+02	1.000E+01	1.187E+01	1.879E-01	3.024E+00
30	1.963E+02	2.139E+02	1.004E+01	1.195E+01	1.882E-01	3.036E+00
31	1.961E+02	2.138E+02	1.002E+01	1.194E+01	1.880E-01	3.036E+00
32	1.970E+02	2.139E+02	1.012E+01	1.195E+01	1.889E-01	2.776E+00
33	1.966E+02	2.143E+02	1.007E+01	1.199E+01	1.885E-01	2.772E+00
34	1.981E+02	2.146E+02	1.023E+01	1.203E+01	1.900E-01	2.782E+00
35	1.975E+02	2.147E+02	1.016E+01	1.203E+01	1.893E-01	2.778E+00
36	1.975E+02	2.151E+02	1.016E+01	1.208E+01	1.893E-01	2.773E+00
37	1.979E+02	2.156E+02	1.020E+01	1.213E+01	1.897E-01	2.781E+00
38	1.973E+02	2.156E+02	1.013E+01	1.213E+01	1.891E-01	2.787E+00
39	1.979E+02	2.158E+02	1.020E+01	1.215E+01	1.897E-01	2.771E+00
40	1.977E+02	2.159E+02	1.019E+01	1.217E+01	1.896E-01	2.784E+00
41	1.974E+02	2.159E+02	1.015E+01	1.217E+01	1.892E-01	2.536E+00
42	1.971E+02	2.166E+02	1.012E+01	1.225E+01	1.890E-01	2.527E+00
43	1.960E+02	2.166E+02	1.001E+01	1.225E+01	1.880E-01	2.537E+00
44	1.938E+02	2.167E+02	9.778E+00	1.226E+01	1.857E-01	2.257E+00
45	1.912E+02	2.173E+02	9.520E+00	1.232E+01	1.833E-01	2.270E+00
46	1.875E+02	2.173E+02	9.151E+00	1.233E+01	1.797E-01	2.023E+00
47	1.844E+02	2.175E+02	8.846E+00	1.235E+01	1.767E-01	1.751E+00
48	1.787E+02	2.180E+02	8.302E+00	1.240E+01	1.712E-01	1.768E+00
49	1.762E+02	2.181E+02	8.075E+00	1.242E+01	1.688E-01	1.770E+00

TABLE B5 (CONT.). DOWNSTREAM BLADE-TO-BLADE REDUCED
PROBE DATA FILE U-4SEPACALC

SCAN	PRB POSIT	BETA	GAMMA	PHI	Xvel	Xref
1	0.00	1.853E-02	8.853E-02	-4.111E-03	7.148E-02	8.684E-02
2	.10	1.779E-02	8.983E-02	-4.764E-03	7.008E-02	8.658E-02
3	.20	1.610E-02	1.018E-01	-1.102E-02	6.671E-02	8.630E-02
4	.30	1.493E-02	9.524E-02	-7.663E-03	6.429E-02	8.628E-02
5	.40	1.381E-02	1.002E-01	-1.043E-02	6.181E-02	8.621E-02
6	.50	1.313E-02	1.070E-01	-1.413E-02	6.022E-02	8.620E-02
7	.55	1.304E-02	9.654E-02	-8.619E-03	6.007E-02	8.617E-02
8	.60	1.301E-02	1.054E-01	-1.327E-02	5.996E-02	8.613E-02
9	.65	1.307E-02	1.042E-01	-1.263E-02	6.010E-02	8.605E-02
10	.70	1.336E-02	9.202E-02	-6.184E-03	6.082E-02	8.610E-02
11	.75	1.369E-02	1.029E-01	-1.186E-02	6.153E-02	8.622E-02
12	.80	1.423E-02	1.027E-01	-1.167E-02	6.274E-02	8.624E-02
13	.85	1.519E-02	1.013E-01	-1.083E-02	6.480E-02	8.752E-02
14	.90	1.617E-02	9.750E-02	-8.767E-03	6.686E-02	8.838E-02
15	.95	1.719E-02	9.498E-02	-7.432E-03	6.892E-02	8.878E-02
16	1.00	1.815E-02	9.660E-02	-8.275E-03	7.075E-02	8.947E-02
17	1.05	1.914E-02	8.667E-02	-3.176E-03	7.263E-02	8.973E-02
18	1.10	2.027E-02	8.728E-02	-3.539E-03	7.466E-02	8.999E-02
19	1.15	2.107E-02	8.687E-02	-3.363E-03	7.607E-02	9.017E-02
20	1.20	2.200E-02	7.894E-02	6.477E-04	7.768E-02	9.036E-02
21	1.25	2.282E-02	9.446E-02	-7.283E-03	7.906E-02	9.065E-02
22	1.30	2.346E-02	8.278E-02	-1.351E-03	8.013E-02	9.074E-02
23	1.35	2.419E-02	8.302E-02	-1.469E-03	8.133E-02	9.080E-02
24	1.40	2.443E-02	7.724E-02	1.466E-03	8.173E-02	9.059E-02
25	1.45	2.493E-02	7.817E-02	1.007E-03	8.254E-02	9.081E-02
26	1.50	2.528E-02	7.916E-02	5.131E-04	8.310E-02	9.077E-02
27	1.55	2.553E-02	7.892E-02	6.459E-04	8.351E-02	9.103E-02
28	1.60	2.565E-02	8.306E-02	-1.447E-03	8.370E-02	9.118E-02
29	1.65	2.566E-02	8.188E-02	-8.475E-04	8.372E-02	9.110E-02
30	1.70	2.574E-02	7.319E-02	3.562E-03	8.386E-02	9.140E-02
31	1.75	2.570E-02	1.264E-01	-2.334E-02	8.378E-02	9.136E-02
32	1.80	2.596E-02	9.390E-02	-6.922E-03	8.420E-02	9.139E-02
33	1.85	2.584E-02	8.539E-02	-2.619E-03	8.401E-02	9.156E-02
34	1.90	2.625E-02	1.247E-01	-2.247E-02	8.467E-02	9.170E-02
35	1.95	2.607E-02	1.291E-01	-2.471E-02	8.438E-02	9.172E-02
36	2.00	2.607E-02	1.292E-01	-2.473E-02	8.437E-02	9.189E-02
37	2.05	2.617E-02	9.404E-02	-6.975E-03	8.454E-02	9.208E-02
38	2.10	2.599E-02	9.173E-02	-5.821E-03	8.426E-02	9.209E-02
39	2.15	2.618E-02	9.126E-02	-5.569E-03	8.455E-02	9.218E-02
40	2.20	2.613E-02	9.622E-02	-8.083E-03	8.447E-02	9.224E-02
41	2.25	2.603E-02	9.197E-02	-5.938E-03	8.432E-02	9.222E-02
42	2.35	2.597E-02	1.400E-01	-3.020E-02	8.422E-02	9.252E-02
43	2.45	2.569E-02	1.426E-01	-3.151E-02	8.376E-02	9.255E-02
44	2.55	2.508E-02	9.057E-02	-5.278E-03	8.278E-02	9.259E-02
45	2.65	2.441E-02	1.121E-01	-1.619E-02	8.169E-02	9.282E-02
46	2.75	2.345E-02	1.098E-01	-1.506E-02	8.010E-02	9.282E-02
47	2.85	2.265E-02	1.035E-01	-1.188E-02	7.877E-02	9.290E-02
48	2.95	2.123E-02	1.072E-01	-1.374E-02	7.633E-02	9.311E-02
49	3.00	2.064E-02	1.105E-01	-1.547E-02	7.528E-02	9.319E-02

TABLE B5 (CONT.). DOWNSTREAM BLADE-TO-BLADE REDUCED
PROBE DATA FILE U-4SEPACALC

SCAN	Pref-Pt/Qref
1	3.650E-01
2	3.889E-01
3	4.490E-01
4	4.919E-01
5	5.331E-01
6	5.584E-01
7	5.628E-01
8	5.633E-01
9	5.632E-01
10	5.527E-01
11	5.417E-01
12	5.238E-01
13	5.062E-01
14	4.834E-01
15	4.529E-01
16	4.282E-01
17	3.963E-01
18	3.631E-01
19	3.374E-01
20	3.068E-01
21	2.827E-01
22	2.606E-01
23	2.361E-01
24	2.232E-01
25	2.076E-01
26	1.937E-01
27	1.879E-01
28	1.871E-01
29	1.822E-01
30	1.860E-01
31	1.865E-01
32	1.770E-01
33	1.833E-01
34	1.718E-01
35	1.799E-01
36	1.837E-01
37	1.831E-01
38	1.883E-01
39	1.840E-01
40	1.856E-01
41	1.902E-01
42	1.981E-01
43	2.101E-01
44	2.306E-01
45	2.559E-01
46	2.931E-01
47	3.201E-01
48	3.700E-01
49	3.912E-01

.....

ENSEMBLE AVERAGES

PPAVG	PAAVG	TEMPAVG	XREFAVG	VREFAVG	QREFAVG
1.172E+01	405.20E+00	455.84	9.007E-02	2.108E+02	1.160E+01

TABLE B6. BLADE SCALED DATA FILE B-4SEFASCL

FROM DATA ASSOCIATED WITH THE BLADE DATA IS CONTAINED
IN FILE: L-4SEFASCL

SCAN: 31	
SCAN/VALUE	FRESS (INCHES H2O)
PORT	
1	8.000E-03
2	1.487E+01
3	1.284E+01
4	-3.614E+00
5	-1.134E+00
6	2.300E-01
7	8.600E-01
8	9.520E-01
9	9.200E-01
10	6.640E-01
11	9.020E-01
12	6.600E-01
13	1.002E+00
14	1.646E+00
15	2.428E+00
16	2.182E+00
17	1.482E+00
18	1.812E+00
19	2.356E+00
20	4.026E+00
21	4.906E+00
22	7.336E+00
23	-1.924E+01
24	-3.436E+01
25	-3.382E+01
26	-2.966E+01
27	-2.221E+01
28	-1.806E+01
29	-1.436E+01
30	-1.304E+01
31	-1.105E+01
32	-8.656E+00
33	-7.204E+00
34	-5.974E+00
35	-5.214E+00
36	-4.570E+00
37	-4.060E+00
38	-3.906E+00
39	-3.716E+00
40	-3.502E+00
41	-3.254E+00
42	-3.156E+00
43	-7.160E-01
44	-9.750E+00
45	-3.566E+00
46	1.612E+00
47	9.860E-01
48	-2.836E+00

TABLE B7. BLADE REDUCED DATA FILE B-4SEPACALC

SCANIVALVE PORT	MASS AVERAGED COEFFICIENT OF PRESSURE
4	2.133E-01
5	3.507E-01
6	4.263E-01
7	4.612E-01
8	4.663E-01
9	4.646E-01
10	4.515E-01
11	4.636E-01
12	4.513E-01
13	4.691E-01
14	5.160E-01
15	5.481E-01
16	5.345E-01
17	4.957E-01
18	5.140E-01
19	5.463E-01
20	6.367E-01
21	6.854E-01
22	8.201E-01
23	-6.524E-01
24	-1.525E+00
25	-1.460E+00
26	-1.230E+00
27	-8.171E-01
28	-5.869E-01
29	-4.153E-01
30	-3.092E-01
31	-1.986E-01
32	-6.606E-02
33	1.440E-02
34	8.255E-02
35	1.247E-01
36	1.604E-01
37	1.886E-01
38	1.971E-01
39	2.077E-01
40	2.195E-01
41	2.333E-01
42	2.386E-01
43	3.739E-01
44	-1.267E-01
45	2.149E-01
46	5.029E-01
47	4.682E-01
48	2.531E-01

2. RETURN
3. Press LOAD
4. Type INITFLEX between quotation marks. [The root directory based INITFLEX program formats the disc.]
5. RETURN
6. Press RUN
7. Follow the prompts--the process takes a few minutes.

Once the disc is formatted, it can be used to back up files. To load the root directory-based BACKUP program, use the following steps:

1. Type MSI"/"
2. RETURN
3. Press LOAD
4. Type BACKUP between quotation marks
5. RETURN
6. Press RUN
7. Press SELECT. [The arrow indicator will be at the desired position i.e., "Backup selected files."]
8. Type /CLASSICK/DESIRED SUBDIRECTORY/= :CS80,700
9. RETURN
10. Press PROCEED. [Use arrow keys to move indicator to flexible disc option.]
11. Press SELECT
12. Press YES. [Note the caution]

The backup process proceeds to completion, displaying each file transferred to the flexible disc. If there are too many files for one disc, a prompt for an additional disc

will be displayed. Note that the files generated by "CALC" consume a lot of disc space. Upon completion,

13. Press UNLDTAPE

14. Press DONE

B.9 RECOMMENDATIONS

The method of obtaining probe survey data can be improved upon by making changes to the three main programs and including software additions. Changes to the programs will provide higher quality data, reduce the chance of erroneous entries and make computations more efficient. Software additions will enhance data recovery and reduce the chance of mistakenly deleting data files. Specific recommendations are:

1. Improve the existing DVM error trap. Occasional surges in the facility's power supply cause spurious DVM readings. Spurious DVM readings are trapped by the Maxdif variable on line 91 of "ACQUIRE" and the IF-THEN structure in the subprogram "Readdvm". The existing trap is adequate for Scanivalve port readings but not for yaw transducer readings. A separate Maxdif value, and incorporation into "Readdvm", is required for the yaw transducer. Alternately, a subroutine to statistically analyze and reject spurious DVM readings could be added to "Readdvm", [A more extensive but permanent solution is to rectify the power surge problem.]

2. Dynamically size the CALC array in program "CALC." This is done in "ACQUIRE" with the Rawdat and Scaled arrays. Dynamic sizing would reduce the amount of disc space the reduced data files from "CALC" consume.

3. Eliminate the need in "ACQUIRE" for scan number and position entries by the user for each data point. For repetitive surveys with a known number of data points and probe displacement interval, a data file could be used to supply those values.

4. Combine "CALC" and "LOSS." The AVDR and loss coefficient could be calculated within the structure that calculates C_p . While this would eliminate one program, it would complicate the structure of "CALC" somewhat and make the structure more difficult for a new user to grasp.

5. Create a subdirectory for the scaled data files from "ACQUIRE." This would eliminate the clutter of files in the REDDATA subdirectory, and make the file system consistent with the distinction that program "CALC" makes between scaled and reduced data files. A cluttered file system increases the chances of losing a valuable file during a purge. This addition would require change to the MSI statements on lines 130, 374, 581 and 763 in "ACQUIRE" and line 130 in "CALC." A MSI `"/CLASSICK/REDDATA"` would have to be inserted before

line 134 to allow access to the probe coefficients file stored in the subdirectory READDATA.

6. Develop a program to print a tabulation of the data stored in the scaled data files. This tabulation should duplicate the format in "ACQUIRE." The program can be produced by appropriate additions and deletions to "ACQUIRE" since the formatted print statements already exist. [See Chapter 11, Ref. 13.]

B10. FOR THE USER - SUMMARY OF PROGRAM STEPS

All commands except RETURN are executed by pressing the set of keys f1 - f8 corresponding to the soft key labels appearing at the bottom of the screen. RETURN is the key found on the main keyboard.

The following is a summary of program steps:

1. DVM, Scanner and Scanivalve Controller--ON
2. Disc Drive--ON
3. Disc Drive Amber Lights--EXTINGUISHED
4. Computer, Monitor and Printer--ON
5. LOAD "/CLASSICK/PROGS/ACQUIRE"
6. RETURN
7. RUN
8. Type raw data file name for probe survey without quotation marks.
9. RETURN
10. Type scaled data file name for probe survey.
11. RETURN

12. Type atmospheric pressure in inches Hg.

13. RETURN

14. Press ONE PROBE or TWO PROBES

15. Type scan number and probe position. For two probe option, type scan number, lower probe position and upper probe position.

16. RETURN

17. Press REPEAT or RECORD

[REPEAT returns prompt for scan number and position of data point to be repeated. Record stores data to the file.]

18. Press GO ON or END PRB DATA

[GO ON, returns prompt for scan number and probe position of next data point. END PRB DATA terminates probe data collection.]

19. Press GO ON or COLLECT

[GO ON, by-passes blade data collection and returns print option prompts (Step 20). COLLECT, returns prompt for raw blade data file name.]

a. Type raw blade data file name

b. RETURN

c. Type scaled blade data file name

d. RETURN

e. Press REPEAT or RECORD

[REPEAT, repeats the blade pressure scan RECORD, stores data to the file.]

20. Follow the print option prompts

Note that this is the only time to obtain a hard copy of the raw and scaled probe and blade data.

21. Press GO ON or CALC

[GO ON, Terminates "ACQUIRE"]

Note that "CALC" can be executed later by the command: LOAD "/CLASSICK/PROGS/CALC" CALC, Loads and executes "CALC"]

22. Type the scaled probe data file name created in "ACQUIRE."

23. RETURN

24. Type the probe calibration coefficient file for X (velocity).

25. RETURN

26. Type the probe calibration coefficient file for Phi (pitch).

27. RETURN

28. Press ONE PROBE or TWO PROBES

[TWO PROBES, will prompt the user for the upper probe calibration coefficient files for X and Phi]

29. Type the file name for the data to be reduced from the scaled data file. For two probes, a second scaled data file name is required.

30. RETURN

31. Press REDUCE DATA after amber light quits blinking.

32. Press GO ON or BLADE Cp's.

[GO ON, returns prompt to load "LOSS" (step 33) BLADE Cp's, prompts for scaled blade data file name.]

a. Type blade scaled data file name

b. RETURN

c. Type the file name for the data to be reduced from the scaled data file.

d. RETURN

e. Type scan number associated with lower limit of integration of probe lower blade-to-blade survey.

f. RETURN

g. Type scan number associated with higher limit of integration of probe lower blade-to-blade survey.

h. RETURN

i. Press BLADE DATA after amber light quits blinking.

33. Press GO ON or LOSS

a. GO ON terminates "CALC". Note that "LOSS" can be executed later by the command:

1. LOAD "/CLASSICK/PROGS/LOSS"

2. LOSS, loads and executes "LOSS"

b. Note that "LOSS" requires upper and lower probe blade-to-blade survey reduced data file names.]

34. Type the lower probe blade-to-blade survey reduced data file name.

35. RETURN

36. Type the upper probe blade-to-blade survey reduced data file name.

37. RETURN

38. Type the scan number corresponding to the lower limit of integration for the lower probe survey.

39. RETURN

40. Type the scan number corresponding to the higher limit of integration for the lower probe survey.

41. RETURN

42. Repeat for upper probe survey.

[Note that integration interval for both upper and lower probes must be exactly equal even though the scan number entries may not be the same.]

43. Program "LOSS" terminates after static pressure rise coefficient, AVDR and loss coefficient are printed to the screen.

APPENDIX C

PROBE YAW ANGLE REFERENCING

Two methods can be used to relate yaw angle measured using the angle vernier (or electrical equivalent), to the locus of the leading edges of the cascade. Both make use of a digital precision inclinometer which measures angles to the horizontal with a resolution of 0.1° . A flat bar must be attached firmly to the probe shaft.

C.1 FREE-JET METHOD

Step 1 Mount the probe in the free-jet from the N side as shown in Figure C1(a).

Balance the probe pneumatically.

Read the angle of the bar (to horizontal) using the inclinometer (Δ_1).

Step 2 Mount the probe in the free-jet from the S side as shown in Figure C1(b).

Balance the probe pneumatically.

Read the angle of the bar (to horizontal) using the inclinometer (Δ_2).

Step 3 If Δ_0 is the angle of the probe pneumatic axis (P.A.) to the surface of the bar, and δ_J is the inclination of the free-jet to the horizontal, then

$$\Delta_1 = \Delta_0 - \delta_J$$

and

$$\Delta_2 = \Delta_0 + \delta_J.$$

Hence

$$\Delta_0 = \left(\frac{\Delta_1 + \Delta_2}{2} \right)$$

$$\delta_J = \left(\frac{\Delta_1 - \Delta_2}{2} \right)$$

Step 4 Mount the probe on the cascade on the N side as shown in Figure C1(c).

Read the vernier when the bar is horizontal (β_H).

Then, the angle of the pneumatic axis to the vertical

$$\beta_{PA} = 90 - \Delta_0 .$$

Angle of the pneumatic axis to the normal to the locus of the leading edges

$$\beta'_{PA} = \beta_{PA} - \delta_B = 90 - \Delta_0 - \delta_B .$$

Rotate probe to balance in the flow. Read the vernier (β_F).

The flow angle, related correctly to the normal to the locus of the leading edges, is given by

$$\begin{aligned} \beta &= \beta'_{PA} + (\beta_F - \beta_H) \\ &= 90^\circ - \Delta_0 - \delta_B + (\beta_F - \beta_H) \end{aligned}$$

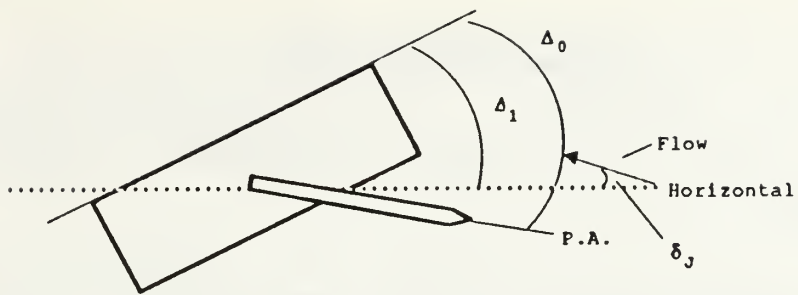
C.2 LDV (IN SITU) METHOD

Mount the probe and balance at a point where β_1 is known from LDV measurements. Read the vernier (β_{F1}). Turn the bar to horizontal. Read the vernier (β_H)

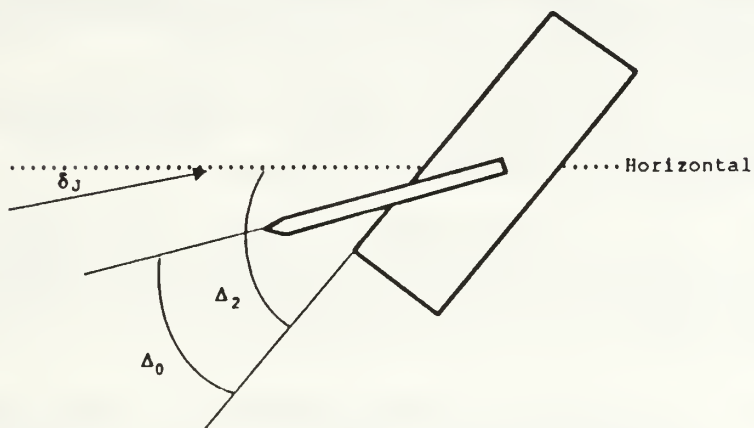
$$\text{then} \quad \beta'_{PA} = \beta_1 - (\beta_{F1} - \beta_H) = (\beta_1 - \beta_{F1}) + \beta_H$$

At any other condition, the inlet air angle is given by

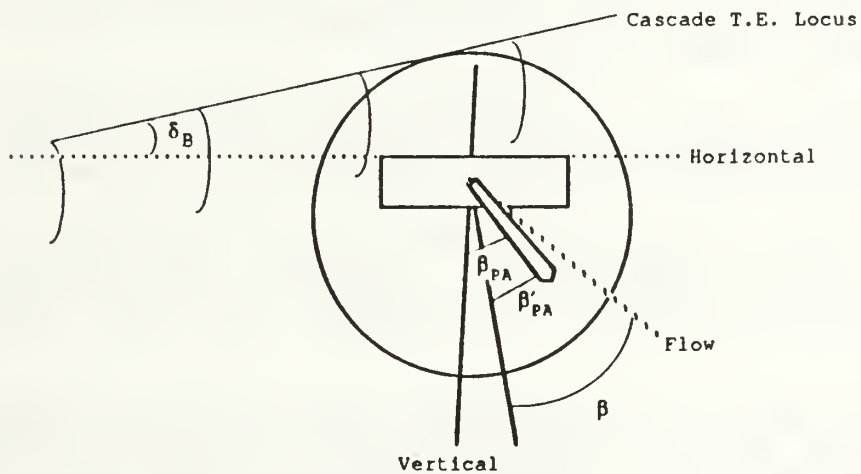
$$\begin{aligned} \beta &= \beta'_{PA} + (\beta_F - \beta_H) \\ &= (\beta_1 - \beta_{F1}) + \beta_F . \end{aligned}$$



a) From N. Side on Free-Jet



b) From S. Side on Free-Jet



c) From N. Side on Cascade

Figure C1. Probe Angle Referencing

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